MACHINERY

July, 1912

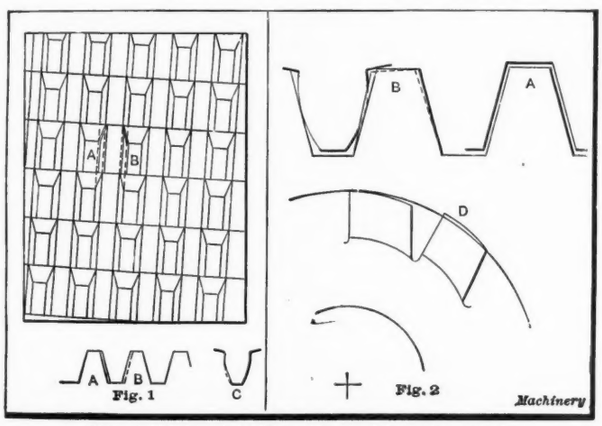
HOBS FOR SPUR AND SPIRAL GEARS*

By JOHN EDGAR†

THE success of the hobbing process for cutting teeth in spur and spiral gears depends as much upon the hob as upon the machine, and at the present stage of development the hob is the limiting factor in the quality of the product. It is well known that hobs at the present time are far from being standardized, and that the product will not be interchangeable if the hob of one maker is substituted for that of another; in fact, the using of two hobs from the same maker successively will sometimes result in the production of gears which will not interchange or run smoothly. This is not a fault of the hobbing process, but is due to the fact that the cutter manufacturers have not given the question of hobs the study it requires. This is also the reason why there are so many complaints about the hobbing machine. Nevertheless, with the proper hob the hobbing machine is the quickest method of machining gears that has ever been devised. Its advantage lies in the continuous action and in the simplicity of its mechanism. There is no machine for producing the teeth of spur gears that can be constructed with a simpler mechanism, and even machines using rotary cutters are more complicated if automatic.

Hobs with Few Teeth give Best Results

The ideal form of hob, theoretically speaking, would be one that had an infinite number of cutting teeth. In practice, however, a seemingly contradictory result is obtained, as hobs

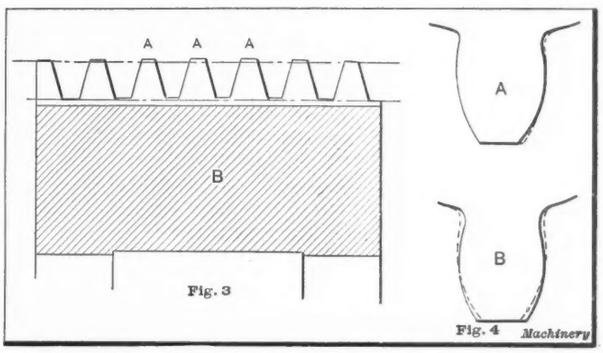


Figs. 1 and 2. Distortion of Hob Teeth and its Effect

with comparatively few teeth give the best results. The reasons for this are due to purely practical considerations. Strictly speaking, a theoretical tooth curve is no more possible when the tooth is produced by the hobbing process than when produced by the shaper or planer type of generator, but for all practical purposes, the curve generated under proper working conditions is so nearly correct as to be classed as a theoretical curve. If this result is not often met with under ordinary working conditions, it is due to the fact that the hob is not as good as present practice is able to make it.

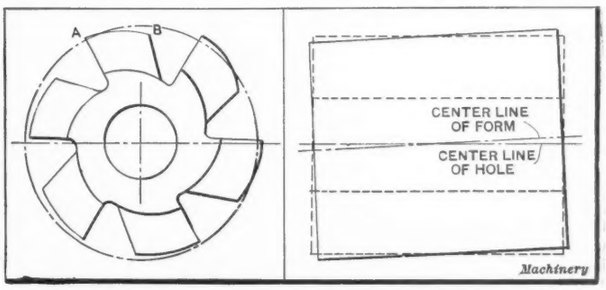
Eccentricity and Variation in Hob Teeth Causes of Defects in Gears

In order to obtain a proper curve and not a series of flat surfaces, the teeth of the hob must follow in a true helical path. In ninety-nine cases out of one hundred the hob is at fault when a series of flats is obtained instead of a smooth curved tooth face. It is the deviation of the teeth of the hob from the helical path that is at the root of most hobbing machine troubles. There are several causes for the teeth being out of the helical path: The trouble may have originated in



Figs. 3 and 4. Distortion of Hobs and Result on the Shape of the Teeth

the relieving or forming of the teeth; the machine on which this work has been done may have been too light in construction, so that the tool has not been held properly to its work, and has sprung to one side or another causing thick and thin teeth in the hob; a hard spot may have been encountered causing the tool to spring; the gashes may not have been properly spaced, or there may have been an error in the gears on the relieving lathe influencing the form; the hob may also have been distorted in hardening; it may have been improperly handled in the fire or bath, or it may have been so proportioned that it could not heat or cool uniformly; the grinding after hardening may be at fault; the hole may not have been ground concentric with the form, thus causing the teeth on one side of the hob to cut deeper than on the other.



Figs. 5 and 6. Hobs with the Center Hole out of True with the Outside of the Tooth Form

Any one or a combination of several of these conditions may have thrown the teeth out of the true helical path.

Fig. 1 illustrates the difficulty of thick and thin teeth. The tooth *A* is too thick and *B* is too thin, the threading tool having sprung over from *A* and gouged into *B*. Fig. 1 also shows a developed layout of the hob. At *C* is shown the effect that thick and thin teeth may have on the tooth being cut in the gear—that of producing a flat on the tooth. This flat may appear on either side of the tooth and at almost any point from the root to the top, depending upon whether the particu-

* For additional information relating to the hobbing process for generating gear teeth, and kindred subjects, see the following articles previously published in MACHINERY; "Unusual Hobbing Operation," May, 1912; "Spiral-fluted Hob Angles," April, 1912; "Farwell Universal Gear Hobbing Machine," March, 1912; "Sharpening a Hob in a Shaper," January, 1912; "Gould and Eberhardt Automatic Hobbing Machine," December, 1911; "Calculating Gears for Generating Spirals on Hobbing Machines," December, 1911, engineering edition; "Sharpening a Hob in a Shaper," October, 1911; "The Gear Hobbing Machine—A Fundamental Defect," June, 1911; "Ins and Outs of Gear Hobbing," June, 1911, engineering edition; "Ins and Outs of Gear Hobbing," February, March, and April, 1911; "A Friendly View of the Hobbing Process," March, 1911; "British Automatic Hob Sharpening and Worm Grinding Machine," February, 1911, engineering edition; "Ins and Outs of Gear Hobbing," January, 1911, engineering edition; "Barber-Colman Gear Hobbing Machine," November, 1910; "Meisselbach-Catucci Hob Grinding Machine," November, 1910; "How Many Gashes Should a Hob Have," April, 1909; "Hob Sharpening Attachment for the Walker Universal Grinder," March, 1909; "How Many Gashes Should a Hob Have," January, 1909, engineering edition; "Gear Cutting Machinery," May, 1908, engineering edition.

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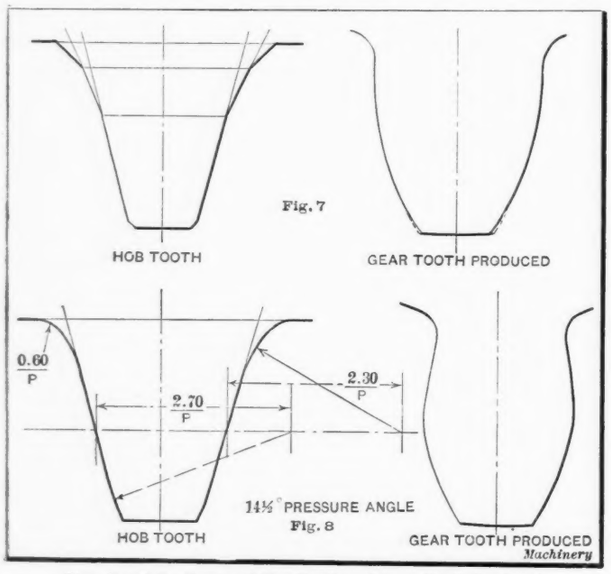
lar hob tooth happens to come central with the gear or not. If it does come central or nearly so, it will cause the hob to cut thin teeth in the blank. The only practical method to make a hob of this kind fit for use is to have it re-formed.

In Fig. 2 is shown at *A* the result of unequal spacing of the teeth around the blank. Owing to the nature of the relief, the unequal spacing will cause the top of the teeth to be at different distances from the axis of the hob. This would produce a series of flats on the gear tooth. One result of distortion in hardening is shown at *B*, Fig. 2, where the tooth is canted over to one side so that one corner is out of the helical path. This defect also produces a flat and shows a peculiar undercutting which at first is difficult to account for. Sometimes a tooth will distort under the effects of the fire in the manner indicated at *D*, Fig. 2.

These defects may be avoided by proper care and by having the steel in good condition before forming. The blank should be roughed out, bored, threaded, gashed and then annealed before finish-forming and hardening. The annealing relieves the stresses in the steel due to the rolling process.

The proportions of the hob have a direct effect on distortion in hardening. This is especially noticeable in hobs of large diameter for fine pitches. Fig. 3 shows the results obtained in hardening a 4-inch hob, 10 pitch, with 1¼ inch hole. There is a bulging or crowning of the teeth at *A*. This is accounted for by the fact that the mass of metal at *B* does not cool as quickly as that at the ends. Consequently, when the hob is quenched, the ends and outer shell cool most quickly and become set, preventing the mass at *B* from contracting as it would if it could come in direct contact with the cold bath and cool off as quickly as the rest of the metal. The effect of this distortion on the shape of the gear teeth is indicated in Fig. 4, where the tooth *A* is unsymmetrical in shape due to the fact that the teeth near the center of the hob cut deeper into the blank, undercutting the tooth on one side and thinning the point. This effect is produced when the gear is centered near the ends of the hob. If the gear is centered midway of the length of the hob, the tooth shape



Figs. 7 and 8. Forms of Hob Teeth and Gear Teeth Produced

produced is as shown at *B*, Fig. 4. This tooth is thick at the point and undercut at the root.

A hob in this condition makes it impossible to obtain quiet running gears. In this case, it would be useless to anneal and re-form the hob, as the same results would be certain to be met with again, on account of the proportions of the hob. Hence, defects of this kind are practically impossible to correct, and the hob should either be entirely re-made or discarded.

Figs. 5 and 6 show in an exaggerated manner two common defects due to poor workmanship. In Fig. 5 the hole is ground out of true with the outside of the tooth form. The hole may run parallel with the true axis of the gear cutter, or it may run at an angle to it, as seen in Fig. 6. The effect of the first condition is to produce a tooth shaped like that shown by the full lines at *B* in Fig. 4, and the effect of that in Fig. 6 is about the same, except that the hob will cut thin teeth when cutting to full depth. Gears cut by either hob will lock with meshing gears, and instead of smooth rolling, the action will be jerky and intermittent.

Gashes which originally were equally spaced may have been unequally spaced by having more ground off the face of some teeth than of others. The greater the amount of relief, the more particular one must be in having the gashes equally spaced.

Grinding to correct Hob Defects

These various faults may be corrected to a greater or less extent in the following manner: Place the hob on a true arbor and grind the outside as a shaft would be ground;

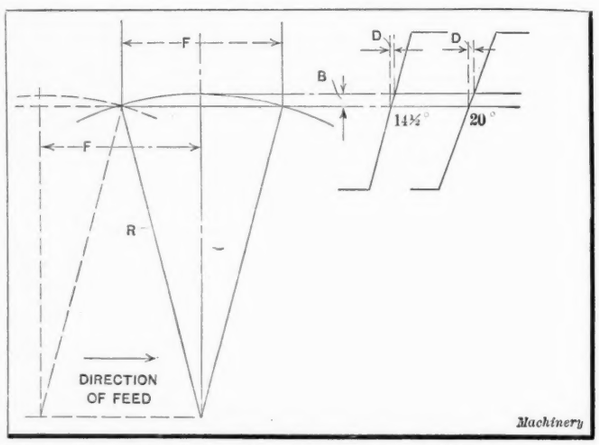


Fig. 9. Illustrating Effect of Feed in Hobbing

touch all of the teeth just enough so that the faintest marks of the wheel can be seen on the tops. The teeth that are protruding and would cause trouble, will, of course, show a wide ground land, while on those that are low, the land will be hardly visible. Now grind the face of each tooth back until the land on each is equal. This will bring all the teeth to the same height and the form will run true with the hole. To keep the hob in condition so that it will not be spoiled at the first re-sharpening, grind the backs of the teeth, using the face as a finger-guide, the same as when sharpening milling cutters, so as to remove enough from the back of each tooth to make the distance *AB*, Fig. 5, the same on all the teeth. Then, when sharpening the teeth in the future, use the back of the tooth as a finger-guide. If care is taken, the hob will then cut good gears as long as it lasts. It is poor practice to use the index head when sharpening hobs, because the form is never absolutely true with the hole, and unless the hob has been prepared as just described, there is no reliable way to sharpen it. If the hob, after having been prepared as described, is sharpened on centers by means of indexing, it will be brought back to the original condition.

The defect shown in Fig. 6 is corrected in the same manner. The gash when so ground will not be parallel with the axis in a straight-fluted hob, nor will it be at an exact right angle with the thread helix in a spiral-fluted hob, because the teeth at the right-hand end are high while those at the left-hand end are low, and the amount that must be ground off the faces of the hob teeth will be greater at one end than at the other. The angle will be slight, however, and of no consequence.

Shape of Hob Teeth

The first thing that is questioned when a hob does not produce smooth running gears is the shape of the hob tooth. The poor bearing obtained when rolling two gears together would, in many cases, seem to indicate that the hob tooth was of improper shape, but in nearly every case the trouble is the result of one or more of the defects already pointed out.

Theoretically, the shape of the hob tooth should be that of a rack tooth with perfectly straight sides. This shape will cut good gears from thirty teeth and up, in the 15-degree involute system, but gears under thirty teeth will have a reduced bearing surface as a result of undercutting near the

base circle, which increases as the number of teeth grows smaller. The shape produced by such a hob, if mechanically perfect, would be a correct involute, and the gears should interchange without difficulty. In order that the beginning of contact, however, may take place without jar, the points of the teeth should be relieved or thinned, so that the contact takes place gradually, instead of with full pressure. This is accomplished by making the hob tooth thicker at the root, starting at a point considerably below the pitch line. This is illustrated in Fig. 7, which shows the standard shape adopted by the Barber-Colman Co. The shape of the tooth produced is also shown. The full lines show the shape generated, and the dotted, the lines of the true involute. The amount removed from the points is greater on large gears and less on small pinions, where the length of contact is none too great even with a full shaped tooth, and where any great reduction must be avoided. This shape of hob tooth does not, however, reduce undercutting on small pinions. The fact that hobbed gears have undercut teeth in small pinions, while those cut with rotary cutters have radial flanks with the curve above the pitch line corrected to mesh with them is the reason why hobbed gears and those cut with rotary cutters will not interchange.

In Fig. 8 is shown a hob tooth shape which will produce teeth in pinions without undercutting, the teeth, instead, having a modified radial flank. The radii of the correction curves are such that the gear tooth will be slightly thin at the point to allow an easy approach of contact. The shape shown in Fig. 8 is approximately that which will be produced on hobs the teeth of which are generated from the shape of a gear tooth which it is desired to reproduce.

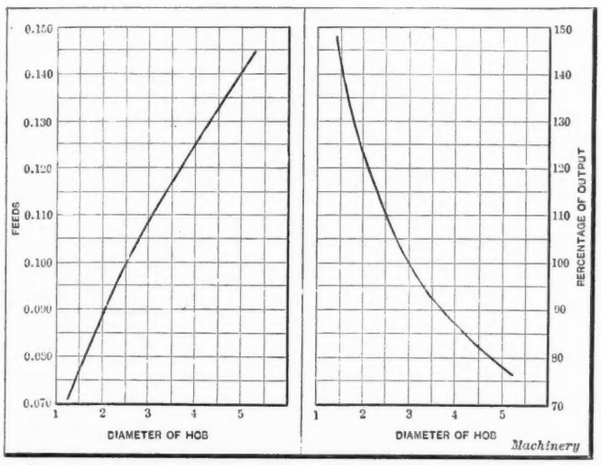


Fig. 10. Diagram showing Comparative Feeds for Hobs of Various Diameters

Fig. 11. Diagram showing Comparative Output of Hobs of Various Diameters based on 3-inch Hob

Diameters of Hobs

The diameters of hobs is a subject which has been much discussed. Many favor large hobs because the larger the hob the greater the number of teeth obtainable. This, however, has already been shown to be a fault, because the greater is the possible chance of some of the teeth being distorted. For the same feed, the output of a small hob is greater, because of being inversely proportional to the diameter. The number of teeth cut is directly proportional to the number of revolutions per minute of the hob. The number of revolutions depends on the surface speed of the hob; therefore, the small hob will produce more gears at a given surface speed.

It may be argued that, on account of the large diameter, the large hob can be given a greater feed per revolution of the blank than the smaller hob, for a given quality of tooth surface. This argument is analyzed in Fig. 9. Let R be the radius of the hob and F the feed of the hob per revolution of the blank. Then B may be called the rise of feed arc.

Since the surface of the tooth is produced by the side, the actual depth of the feed marks is D, which depends on the angle of the side of the tooth, the depth being greater for a 20-degree tooth than it would be for a 14½-degree tooth for the same amount of feed. The relations between F, R, and B may be expressed as follows:

$$F = 2\sqrt{2RB - B^2}$$

Since B is a very small fractional quantity, B^2 would be much smaller and can, therefore, be disregarded, giving the very simple approximate formula $F = 2\sqrt{2RB}$. A rise of 0.001 inch would mean a depth D of about 0.00025 inch on a 14½-degree tooth. The allowable feed is 0.126 inch for a 4-inch hob and 0.108 inch for a 3-inch hob for a 0.001 inch rise. The curve in Fig. 10 shows the feeds for this rise for various hob diameters. Fig. 11 shows a curve based on a 3-inch hob that shows the comparative output for an equal rise. This curve shows that the smaller hob is superior in matter of production.

The larger hobs are also more liable to distortion in hardening and they do not clear themselves as well as the smaller ones when cutting; consequently, they need a greater amount of relief. Large hobs also require a greater over-run of feed at the end of the cut. When cutting spiral gears of large angles this greatly reduces the output, as the greater amount of feed required before the hob enters to full depth in the gear is a pure waste.

The question of whether the gashes or flutes should be parallel with the axis or at right angles to the thread helix has two sides. From a practical point of view, it appears to make very little difference in the results obtained in hobs of small pitch and angle of thread. In hobs of coarse pitch, however, the gashes should undoubtedly be normal to the thread. The effect of the straight gash is noticed when cutting steel, in that it is difficult to obtain a smooth surface on one side of the tooth, especially when cutting gears coarser than 10 pitch. What has been said in the foregoing, however, applies equally to straight and spirally fluted hobs.

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MOVING PICTURES IN THE INDUSTRIES

At the Turin Exposition last year, the Siemens-Schuckert Works had arranged for an exhibition of moving pictures showing the processes of manufacture in their works, and also the performance of machinery built by them, when installed and in use. These exhibitions of moving pictures were highly appreciated by the visitors at the exposition, which showed processes of manufacture in a manner hitherto unrivaled. The highly educational value of exhibitions of this kind has been thoroughly appreciated by educational authorities, and the Siemens-Schuckert Works have offered to exhibit the pictures free of cost before the higher grades in the public schools in Germany. These pictures show clearly and explicitly how small motors are being built at the Charlottenburg works of the firm, how the housings are bored, the pole pieces made, the armatures wound, and the motors assembled.

Another film shows complete blast furnaces and steel mill processes, where the work of producing iron and steel can be observed without the discomfort from heat, smoke and dust accompanying the actual inspection. The loading of the ore from the vessels onto railway cars by means of electric cranes at the Walsum harbor is shown at the beginning, and the raw material is then followed until it is finally rolled into commercial shapes in a steel mill driven by a Siemens-Schuckert motor of 10,000 K.W. maximum capacity.

Still another film shows the use of the electric motor in agricultural fields. An electric plough is illustrated at work, in this case. A number of other interesting operations in various engineering fields where electric motors are used are also shown. Certainly no better method for instructing pupils in public schools of the actual processes of the world's work could possibly be devised. It would not be surprising if the instruction in the schools of the future would be largely by means of moving pictures, at least when subjects relating to the engineering fields, geography and the natural sciences are covered.

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Samples of cloth made in England by a process recently discovered, from the fiber of a species of sea-weed found in southern seas, have been received by the Bureau of Manufactures in Washington. The fiber, after treatment, is soft, pliable and strong, somewhat similar to wool, and easy to spin. It also takes dyes well, except green.

PIERCING AND EMBOSSING DIE FOR AN AUTOMOBILE HEAD LAMP FRONT

By ARON LAWRENCE*

The piercing and embossing die shown in Fig. 2 was designed to pierce eight holes in the periphery of the automobile head lamp front shown in Fig. 1, and at the same time to emboss an arch-shaped rib around the sloping neck portion. This rib or ledge is used to support the head of the lamp when assembled to prevent it from being buckled out of shape

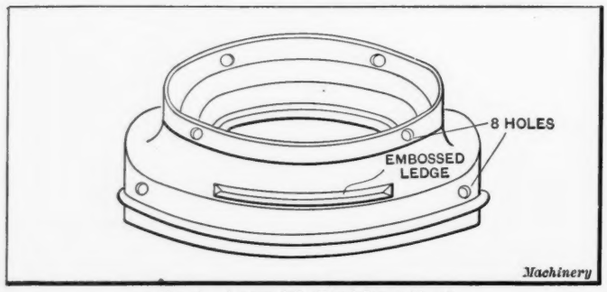

Fig. 1. Automobile Head Lamp Front

when polishing. The pierced holes are for attaching the front to the lamp body, and also for fastening the door hinge and catch.

Referring to Fig. 1, it will be seen that the punches for the body rivet holes in the small diameter or top portion of the front must have a considerably longer stroke than the punches for the hinge and catch holes. The base *A* of the die shown in Fig. 2, is a gray iron casting bored out in its upper central portion to fit the locating ring *B*, also made of cast iron. The ring *B* is fastened to base *A* with large screws and dowels. The piercing die bushings *C* and *D* are pressed into the locating ring *B*, and are made from hardened tool steel. The scrap from the punches passes in toward the center of the die and falls down through the opening to the bolster plate. The hardened tool-steel embossing punch *E* is let into the ring *B*, as shown in the section at *X*—*X*, and is fastened to it by suitable screws.

Cast integral with the base *A* are two blocks projecting upward for the reception of the hinge and catch punches, and four blocks for the punches used in piercing the holes in the body. The shape of these blocks is clearly shown in the sectional views at *Y*—*Y* and *Z*—*Z*, respectively. The punches *F* are of hardened tool steel, set into the heavy punch carriers *G*, which are provided with a tool block *H* against which a helical compression spring acts to withdraw the punches. The punches are operated by the angular-faced lugs *I*, cast integral with the upper portion *T* of the die. The punch holders *G* are slotted out to receive a cross-pin *J*, which limits the length of the return stroke.

The lower punches *K* are similar in construction to those just described except that the punch carriers *L* are shouldered and are returned by means of helical springs *M*, held in counterbored holes in projecting bosses on the base *A*. The punches are limited in their outward travel by a pin *N* which works in an elongated slot in the base. This pin also serves to preserve the proper alignment of the angular end of the carrier *L* under the angular projections *I*. Oil holes are provided for the proper lubrication of the various plungers.

The embossing die *O* is of hardened tool steel, set into a cast-iron ring *P*, which slides vertically below the upper die member *T*, being guided by four steel pins *Q*, and limited in its travel by the shoulder screws *R*. A heavy rubber ring *S*, of sufficient resiliency to accomplish the embossing before further compressing, is introduced between the ring *P* and the casting *T*. Of course this rubber ring must be under initial tension or it will not operate properly.

In operation, the die is used in a heavy arch press with a stroke of about 8 inches; the piece, Fig. 1, is located over the ring *B*, and the press is tripped. The arch-shaped rib is first embossed, after which the rubber ring compresses, allowing the piercing punches to be operated. This method of holding the work while forming and piercing insures the correct relation between the various holes.

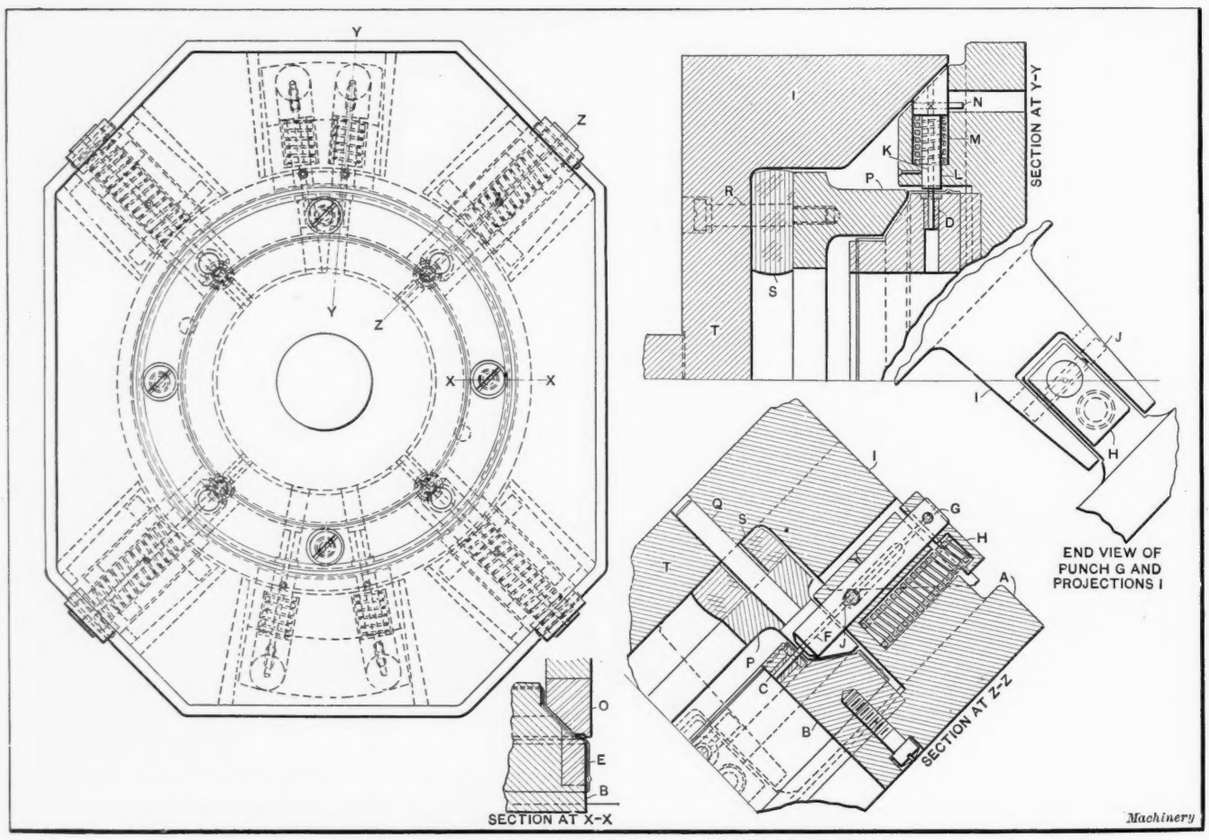

Fig. 2. Piercing and Embossing Die for Automobile Head Lamp Front

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The value of good appearance does not apply merely to the machine being built, but will return dividends when applied also to the appearance of the factory, both inside and outside.

* Address: Detroit, Mich.

GRINDING AND CORRUGATING FLOUR MILL ROLLS*

By F. B. JACOBS†

In the process of flour milling, the grain is first fed between spirally corrugated rolls, generally called breaking-down rolls. The rolls in common use are from six to twelve inches in diameter, and from one to three feet in length, and are made

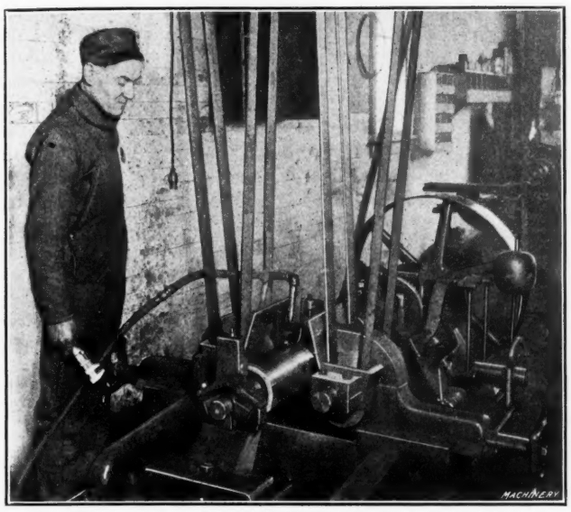

Fig. 1. The Grinding of Corrugated Flour Mill Rolls

of cast iron, the surface of which is chilled to a depth of from one-half to two inches. The crushing of the grain which often contains foreign substances, nails, pebbles, etc., soon wears away the corrugations. In this case the rolls are repaired by grinding away the worn corrugations in a regular roll-grinding machine, and cutting new corrugations in a machine built especially for the purpose. The machine shops of

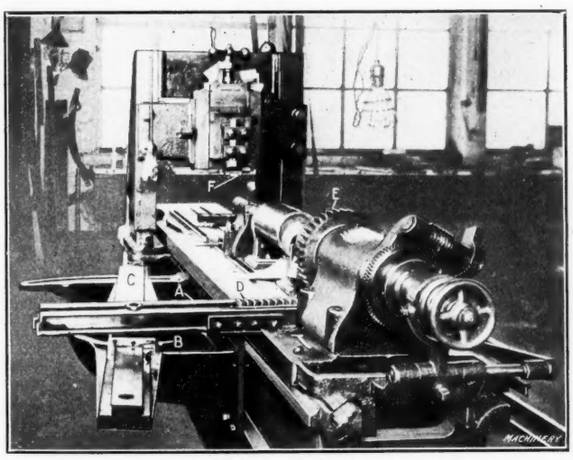

Fig. 2. Machine for Corrugating the Rolls

the larger milling concerns are equipped for this purpose; the smaller milling concerns, however, depend on contract shops which make a specialty of this class of work.

The grinding operation is shown in Fig. 1, the roll being located by its journals or necks and driven by a shaft having two toggle-joints. The object of the toggle-joints is to overcome the tendency of cramping. The grinding wheels used on this machine are carborundum, 10½ inches in diameter, 1½-inch face, 80 grit, K grade, G-4 bond, and are run at a surface speed of approximately 5000 feet per minute. The roll shown is 6 inches in diameter and 12 inches long, and is revolved at a speed of 40 revolutions per minute. The traverse speed is ¾ inch advance for each revolution of the work. When removing 1/32 inch, the grinding time on this roll was 12 minutes and the finish left was excellent. In grinding rolls of this kind, but little attention is paid to size, the object of the grinding being to remove the worn corrugations only. It may be added, however, that it is absolutely necessary that the rolls be parallel. This is accomplished by adjusting the rests that carry the shoes in which the journals run, until the roll is in line with the travel of the wheel carriage. In the roughing operation the depth of cut should be as great as the wheels will stand, which in some cases equals 1/64 inch. The final finish is produced by allowing the wheels to pass the work several times until they cease to spark heavily. With free-cutting wheels, this will be accomplished in a very few passes.

In Fig. 2 is shown the type of machine generally used for the corrugating operation; this, at first glance, looks like an ordinary iron planer equipped with a taper attachment. In Fig. 3 it is seen that the roll is located from its centers and also supported by its journals on V-blocks. In setting up the machine for the corrugating operation, the operator determines the amount of spiral by practically the same method as is used by a toolmaker in setting up a universal milling machine for cutting a spiral cutter. By referring to Fig. 2, it will be seen that the bar *A* is moved by the block *B* which

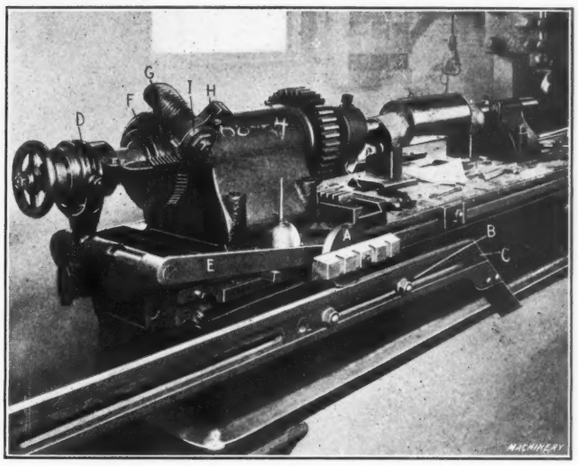

Fig. 3. Indexing Arrangement of Corrugating Machine

travels over the taper slide *C*. The rack *D* meshes with the gear *E* which imparts the spiral motion to the roll. By setting the taper slide at a greater or less angle, different spirals are obtained. This adjustment is of great importance as usually no two rolls, if they come from different milling concerns, have the same spiral, owing to the fact that the various milling concerns hold widely different views regarding the correct spiral for rolls of this kind.

At *A* in Fig. 4 are shown several corrugating tools. These are made of a high grade of tool steel, hardened and drawn to a straw color. As they have several teeth, they work on the principle of a gang tool, thus making it possible to corrugate a roll to the required depth by going around it once. The tool, which is securely clamped in a tool-holder as shown at *F* in Fig. 2, is set at an angle with the roll; thus the first tooth barely scratches the roll, the next going a little deeper and so

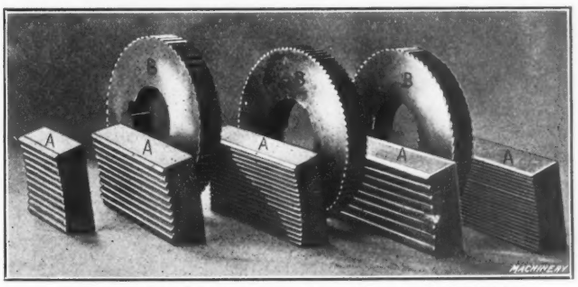

Fig. 4. Tools and Ratchets used in the Corrugating Machine

on until the correct depth is reached by the last tooth. As the material cut is hard chilled iron, the speed for this operation is necessarily slow—one foot in twenty-five seconds. For every stroke of the platen the roll is turned three teeth, this being accomplished by the ingenious arrangement shown in Fig. 3. When the platen is nearing its forward position, the roll *A*,

* See MACHINERY, May, 1909, "Grooving Chilled Flour Mill Rolls," and June, 1906, "Roll Corrugating Device."

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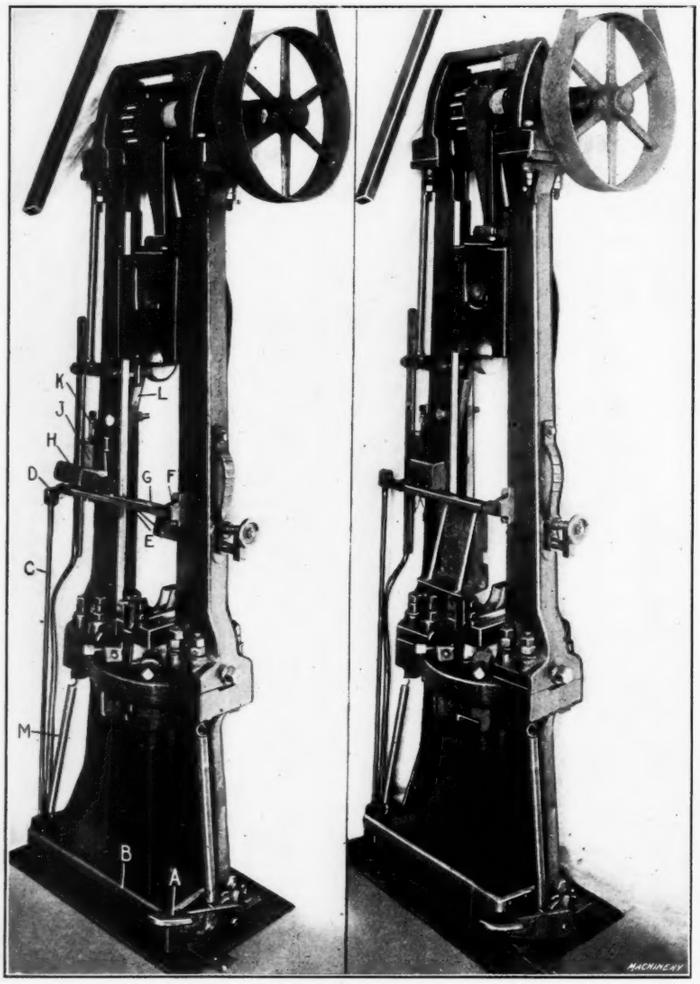
running over the guide *B*, drops upon reaching *C*. By means of the clutch *D*, the lever *E* actuates the rack *F* which turns the sector *G*, thus causing the pawl *H* to slide over the teeth of the ratchet *I*. At the return stroke of the platen, pawl *H* engages the ratchet teeth, thus turning the worm, worm-wheel and roll. By adjusting the slide *B* and substituting different ratchets, a few of which are shown at *B*, Fig. 4, the roll can be turned from one to as many teeth as the operator desires. Where very deep teeth are to be cut, the roll is generally turned one or two teeth for each stroke of the platen. In cutting fine teeth, however, it is often turned several teeth for each stroke.



Figs. 1 and 2. Safety Device applied to a Drop Hammer

As there are many different sizes and shapes of corrugations it is necessary that the machine be provided with adjustments to cover a wide field. The time for corrugating a roll of the same size as shown in the grinding operation, was one hour and fifteen minutes. The corrugations were 0.010 inch deep and spaced twenty to the inch. As roll grinding and corrugating is a special branch of the machinist's trade that calls for skill and judgment along special lines, an expert who is experienced on this particular line of work generally receives the highest wages paid to machinists in the locality in which he is employed.

* * *

In an article in *Industritidningen Norden*, issue of April 12, attention is called to the fact that the Tesla steam turbine described in the November, 1911, number of MACHINERY makes use of a principle which is by no means new, as in 1894, Messrs. P. Nordenfelt and A. Christophe, the former a Swede, the latter a Frenchman, applied for a Swedish patent on the same type of steam turbine, which was granted. This turbine, however, was never developed beyond the experimental stage. Whether or not the Tesla turbine, employing the same principle, will meet with a better fate remains to be seen.

A MECHANICALLY AND ELECTRICALLY OPERATED SAFETY DEVICE

By BENJAMIN C. WAITE, JR.*

The problem of properly equipping machine tools with safety devices is a difficult one and, as a rule, the older the machine, the more difficult it is to guard. A great many firms of late have been forced to properly safeguard their machine tools on account of the stringent laws recently passed for the safeguarding of workers. There is one machine especially which is very difficult to guard, and that is the drop hammer.

In the accompanying illustration an efficient guard for a machine of this type is shown. This guard is operated by moving the foot from the trip lever shown at the lower right-hand side at *A* to the treadle *B* in front of the machine and the operator. The tripping of this extra treadle does not require any more action or effort on the part of the operator than was required before the guard was put on, for previously the foot was in continuous motion from the floor to the trip lever, while now the foot movement is from the trip lever to the treadle, which is held down while the work is removed and replaced. While the foot is in this position, the swinging guard *G* is located as shown in Fig. 1, and is held practically in a horizontal position, being operated by the shaft, crank, and straight rod and spring shown to the left of the hammer. These parts constitute the mechanical connections of the swinging guard.

The electrically controlled parts of the safety device are also shown to the left of the frame immediately above shaft *E*. The box cover *H* protects a small carbon contact switch which opens the circuit when the swinging guard is in the horizontal position, thus causing the dog *L* which is controlled by the magnet *J* and connected to it by the link *K*, to fall into the path of the hammer head, thereby preventing the hammer from falling. Hence the hammer cannot "repeat" or be accidentally tripped, these being the usual causes of most accidents in hammers of this type. When the foot releases the safety treadle *B*, the guard swings down to a vertical position, the circuit is closed, and the magnet, pulling downward, draws dog *L* within the housing of the hammer, providing a clear path for the falling hammer, as soon as it is tripped. While the swinging guard is in the vertical position, as shown in Fig. 2, it is so located that the operator cannot conveniently reach underneath or around it.

This combination of a mechanically and an electrically operated safeguard has been in successful operation for nearly two years, and although there may not be many hammers in use of the exact type shown in the illustration, the principles can be applied to many other tools. An important and unique feature of the device is that should the electrical current fail, the hammer is instantly placed in the safety position, because dog *L* will then immediately fall into the path of the hammer. This condition is shown in Fig. 2.

* * *

TREATING TUNGSTEN FOR WIRE MAKING

A process for increasing the ductility of tungsten so that it can be made into wire for lamp filaments with less difficulty than formerly has recently been patented by Werner von Bolton of Charlottenburg, Germany. The tungsten is treated at a red heat with a mixture of hydrogen and chloride of sulphur. This serves to remove any oxide of tungsten in the metal which is a cause of brittleness. The oxide is converted into sulphide which is, in turn, decomposed by the hydrogen. The metal thus purified contains some sulphur. It is heated to a white heat in a vacuum furnace to expel it, when pure, metallic tungsten of great ductility is obtained which can be easily drawn into wire. When the oxide is reduced by hydrogen in the usual manner, some hydrogen is left which causes brittleness; by the sulphur method, this is avoided.

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WATCH CASE MANUFACTURE*—1

COMPOSITION PLATE—TYPES OF CASES—FORMING CENTER, CAP, BACK AND BEZEL—THREADING

A watch case is simply a metal box which acts as a container for the movement and protects it from injury and dust. Watch cases are made from alloyed gold (pure gold—24 carat—is too soft), silver, gunmetal and other composition metals. A material which is used extensively is what is known as "gold filled"; this consists of a bar of composition metal to which a thin strip of gold is soldered. These built-up bars, shown at *A* and *B* in Fig. 2, are rolled out to the desired thickness, and worked up in punch presses to form the various members of the case. A gold filled watch case wears as well if not better than a solid gold case, does not tarnish, and is a stronger protector for the movement.

Preparing the Gold-plated Bars

Considerable experience is necessary, in preparing gold-plated bars, to produce a uniform thickness of gold on the surface of the bar. The gold plate, of course, is much softer than the composition metal to which it is soldered, and does not harden as quickly or as much during the rolling operation as does the composition metal. Hence, it is absolutely necessary to have a perfect union between the two metals.

Before uniting the gold strip and composition bar, it is necessary that the surfaces which come in contact should be made as nearly true planes as possible. The solder for uniting the composition bar and gold strip is made from alloyed silver, which is rolled out to the proper thickness. The composition bar, solder and gold strips are first coated with soldering acid on those faces which come in contact. If the plated bar is to be used for a bezel, center or cap, it is furnished with a gold plate on one side only, but if the bar is to be used for the back of either a screw or hinged case, a strip of gold is soldered to both faces, as shown at *B* in Fig. 2.

After the bar has been prepared in this manner it is wired so that the various strips will be held in close contact with each other. Then it is placed in a furnace where it is heated to about 1000 degrees F., which is sufficient to melt the solder and join the various strips. When the bar has remained in the furnace long enough for the solder to melt, it is taken out and allowed to cool off gradually. The wires used in binding are then removed, leaving the bar in a condition to be rolled out into a sheet of the desired thickness. The bar is first passed through "breaking-down" rolls, and after about ten passes through the rolls, it is annealed and pickled. This procedure is continued until the bar is rolled out into a strip of approximately the desired thickness. To bring the strip to the exact thickness, it is passed through finishing rolls which give it a better surface.

Types of Watch Cases Manufactured

At the present time there are six distinct types of watch cases made. The first and the most common is the open face case, shown at *A* in Fig. 1. This consists of a center *a*, cap *b*, back *c*, and bezel *d*. The stem *e*, pendant *f*, crown *g*, and bow *h*, of course, are common to all ordinary watch cases. Another type of case which has come into prominence of late is the screw case shown dismantled at *B*, *C* and *D*. This consists of a center, back and bezel, the center *B*, back *C*, and bezel *D* being threaded so that the various parts of the case can be screwed together. There are other cases which are made to suit individual requirements and consequently are of a special nature. There are four cases, however, which are made regularly: the hunting case, consisting of a center, cap, two backs and a bezel; the cup case, consisting of a screw-cup, bezel and a ring to hold the watch movement; the swing-ring case, consisting of a center, cap, bezel, and swing ring; and the bracelet case consisting of a back, center and bezel. The latter case is made in an open face.

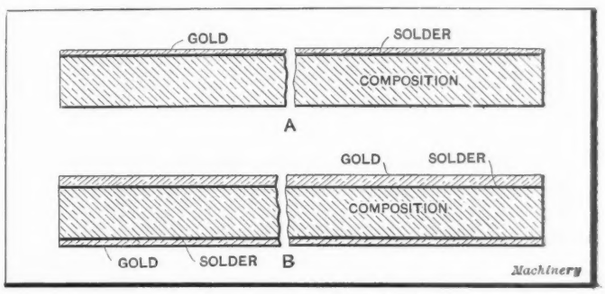


Fig. 2. How the Stock used in making "Gold Filled" Watch Cases is prepared

In this article is given a description of the methods employed in manufacturing an open face case of the type shown at *A*, Fig. 1. Occasional references are also made to the screw case, parts of which are shown at *B*, *C*, and *D*.

Making the Watch Case Center

After the bars previously referred to have been rolled out into strips of the desired thickness, they are cut up in a small power shear into squares, as shown at *A*, Fig. 3. These squares are then taken to the punch press department where they are worked up to form the various members of the case. The case centers are blanked out and cupped up in one operation in a double-action punch press, their condition after the operation being shown at *B*, Fig. 3.

Fig. 1. Hinged and Screw Types of Open-face Watch Cases

From the punch press the cups are taken to the annealing furnace where they are annealed, and then pickled to remove the scale. They are then again taken to a punch press, the next operation consisting in "coaxing over" the top edge of the cup so that it assumes the shape shown at *C*. It is next taken to a spinning machine in which it is given the shape indicated at *D*. The next operation is what is known as the inletting operation for the movement; this consists in turning away the material on the inside edge of the case center, so that it will fit the movement, and is accomplished in the

* For articles on watch making previously published in MACHINERY, see "Watch Movement Manufacture," in the May and June, 1912, numbers, and articles there referred to.

inletting machine shown in Fig. 4. The center, which, by the way, has been fitted up with a pendant, is placed in the spring chuck *A*, the latter being tightened by the knurled nut *B* with a spanner wrench. Tool arbor *C* is now placed in the U-rests *D* and *E*, located at right angles to the axis of the spindle. This tool arbor *C* carries cutters *F*, which are used for making the various cuts, and are held by set-screws in the tool arbor.

In action, the operator grips the tool arbor *C* in both hands, holding it rigidly in the U-rests. He then brings the cutting tools *F*, one at a time, into contact with the work, allowing them to bear or rest on the strip *G*, which is placed across the face of the chuck. The tool arbor is located so that the cutting tools will cut to the correct diameter for the various steps on the case center by means of the stop-screw *H*, held in collar *I*, which comes against the rear face of the U-rest *E*.

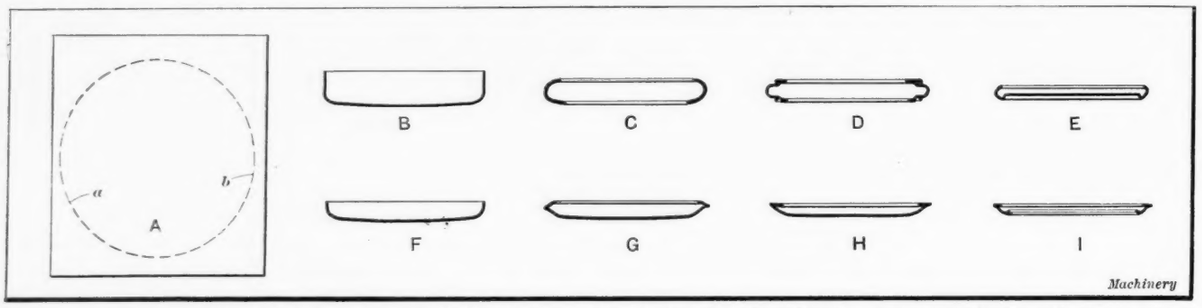


Fig. 3. Evolution and Development of a "Gold Filled" Open-face Jointed Watch Case—Punch Press and Spinning Operations

Threading the Case Center

The case center for the screw back and front type of case shown at *B*, Fig. 1, is threaded in the machine shown in Fig. 5. A case center of the type shown at *A* is placed in the spring chuck *B* and the nut *C* is tightened. The belt *D* is then shifted to run the spindle forward, and the work is prepared for threading by means of the tools held in the turret *E*, which latter is operated by handles *F* and *G*. When the turning is completed, the spindle is reversed to run backward, and the clutch which drives the rear driving shaft through change gears is thrown in by operating the handle *H*. The rear driving shaft carries cams *I* and *J* for operating the tool carriage which holds the circular threading tool *K*. Face cam *I* in conjunction with the change gears traverses the tool-slide longitudinally at the proper speed in relation to the rotation of the spindle, to cut a thread of the desired pitch—40 threads per inch.

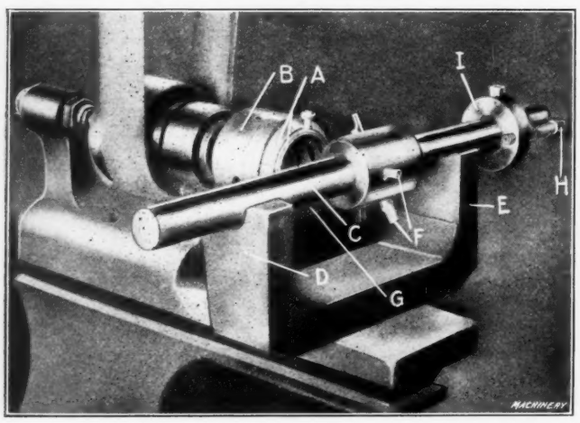


Fig. 4. Inletting the Watch Case Center for the Movement

The threading tool *K* is brought in to and out of action by means of the cam *J* which is timed with cam *I* to bring the tool in to action while the slide is being traversed toward the head of the machine. When the roll attached to the slide drops into a cut-away portion in both cams *I* and *J*, the tool *K* is withdrawn from the work and returned to the starting point by springs. The threading tool is fed in to the correct depth by means of handwheel *L*, operating the top slide *M*, which is provided with an adjustable stop. The case center for the hinged type of case is not threaded, but is jointed. This operation consists in cutting two grooves in the side of the case in which two short pieces of gold-plated hollow wire* are soldered. The grooves are cut with two slitting saws, thus enabling the grooves in both sides of the case center to be cut at the same time.

Making the Cap and Back

The cap and back *b* and *c*, Fig. 1, used in the hinged case for protecting the movement are also made from squares of gold-plated stock which are blanked and drawn up in a double-action punch press. The condition of the cap after this operation is shown at *F* in Fig. 3. The only difference between the back and cap is that the latter is slightly smaller in diameter than the former. After the back and cap are drawn up into the condition shown at *F* they are annealed and pickled after which they are "coaxed" over. The "coaxing" die and punch bend the top edge of the cap over slightly, as at *G*, Fig. 3. After the "coaxing over" operation, the cap is "snapped" by a punch and die, which operation consists in flattening out the edges and forming it so that it fits the center of the case, as indicated at *H*. The die used for the snapping operation also produces the little thumb catch on the edge, which is used for opening the cap. This finishes the cap with the exception of jointing and polishing. The same operations are performed on the back. The jointing consists in soldering a short piece of gold-plated hollow wire on the edge of the cap and back, which, in conjunction with the hollow wire soldered onto the case center, forms the hinges, a piece of gold wire being used as a pin. A seat for the hollow wire is milled in a small milling machine which is provided with a cutter for this purpose, and a chuck for holding the work. The polishing of the cap and back will be taken up in another installment of this article.

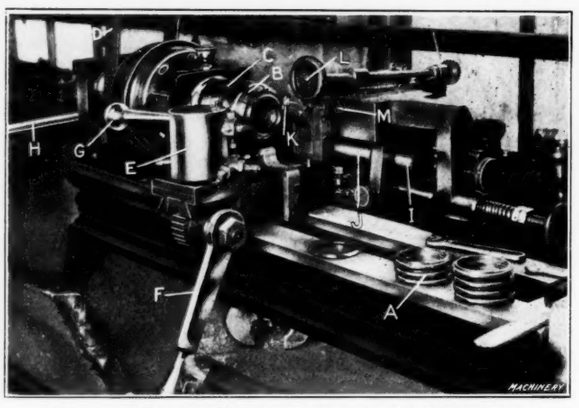


Fig. 5. Cutting the Thread on a Screw Watch Case Center

Threading the Back

The back shown at *c* in Fig. 1, which is used on the screw case is threaded in the machine shown in Fig. 6. The work is held in a draw-in chuck *A*, which is operated by handle *B*. The work spindle is provided with a master thread *C* of the same pitch as that which is to be reproduced on the back—40 threads per inch—and a leader held in the forward end of handle *D* is brought into contact with this master thread

* For information regarding the manufacture of gold-plated hollow wire, see the article entitled "The Making of Seamless Gold Wire," March, 1911, engineering edition.

by the operator. Shaft *E* is connected to the carriage which holds tool-slide *F*, and as this shaft is traversed by the master thread, it evidently carries the tool-slide with it.

Before cutting the thread, the back is prepared for it by a tool *H* which is held on slide *I* and is operated by a foot treadle. When ready for threading, the operator grasps handle *D* with one hand, and operates handle *J* with the other. The leader is brought into contact with the master thread, and at the same instant the circular tool *G* is fed into the work. The handle *D* is then dropped, and the carriage is returned by a spring. The handle *J* feeds the slide in to an

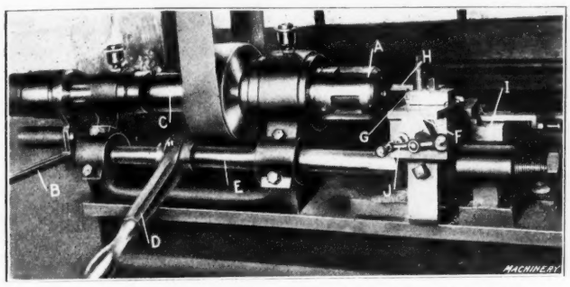


Fig. 6. Cutting the Thread in a Screw Back for a Watch Case of the Type shown at B, Fig. 1

adjustable stop. The screw back is practically completed after the threading operation with the exception of polishing and engine turning.

Making the Bezel

The bezel for the hinged case is shown at *d* in Fig. 1, and also at *E* and *I* in Fig. 3; it is used to retain the glass and is made from a square of gold-plated stock in a similar manner to the other parts of the case. The first operation consists in forming it into a cup, similar to that shown at *F* in Fig. 3. This is accomplished by a combination blanking and cupping die *A*, punch *B*, and plunger *C*, shown in Fig. 7.

After blanking and cupping, the bezel is annealed and pickled; then it is coaxed over in the die *D* by punch *E*. This leaves it in the condition shown at *E* in Fig. 3. After this operation, the bezel is taken to the punch press and the center blanked out with the die *F* and punch *G*, shown in Fig. 7. This leaves the bezel in the condition shown at *I* in Fig. 3, when it is ready for inletting for the glass. This

Fig. 7. Punch Press Tools used in Producing the Bezel for a Jointed Open Face Watch Case

operation is accomplished in a machine of the type shown in Fig. 4. The bezel is then jointed and pinned to the center. The bezel *D*, shown in Fig. 1, which is used on the screw case is threaded in the machine shown in Fig. 6.

* * *

PATENT LAW INVESTIGATING COMMISSION

A special message sent by the president to Congress, relating to the appointment of a commission to investigate the patent laws and report on necessary changes, is one which will be endorsed by all persons who have a wish for the sound development of the country's industries at heart. One of the main reasons given by the president for this message is that the present patent laws make it possible for large corporations to buy up patents and suppress their manufacture, so that the public never receives the benefit of many inventions during the life of the patent. Meanwhile any other inventor is prevented from developing ideas of his own, if they should have enough similarity to the already patented but unused devices to constitute an infringement.

COMBINATION FORMING AND TESTING MACHINE

By F. B. HAYS*

Recently the writer had occasion to make a series of experiments with plastic masses pressed into hard substances of various shapes. As the experiments covered an entirely new field of development, special machines were required for treating the raw materials used in producing the plastic masses, for pressing the latter into the required shape, for accurately determining the pressure used in the compression, and for testing the compressive strength of the shapes after forming. After considerable study and a few preliminary tests the machine shown in Fig. 1 was designed and built for performing the last three operations.

The machine consisted of a heavy cast-iron frame *A*, and a screw *B* operated by a steel gear *C*. This was driven by the pinion *D* which was keyed and pinned to the shaft *E*. The screw was kept from turning by a key. The lower half of the

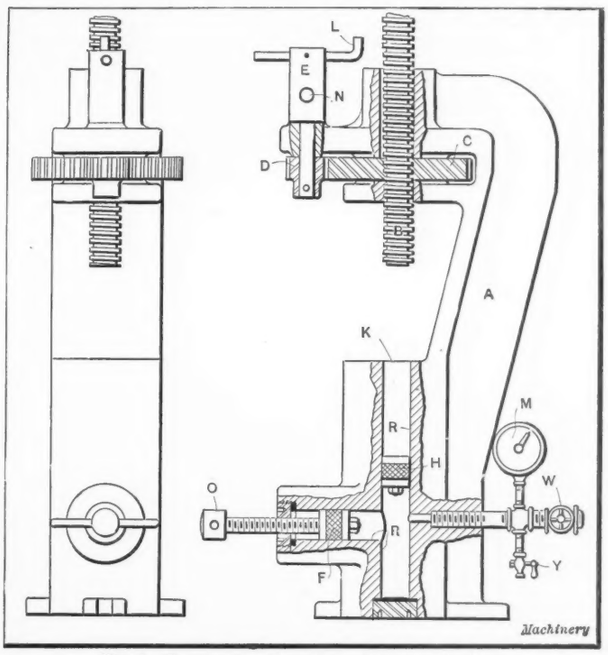
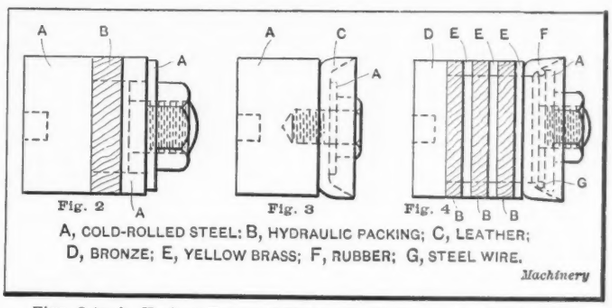


Fig. 1. Combination Forming and Testing Machine

casting was bored and reamed vertically and horizontally as shown, and then bushed by steel tubing *R*, ground externally and internally. The ends of these holes were closed by absolutely tight plugs and gaskets after the pistons *F* and *H* had been inserted into the bushed holes, and the space back of them filled with a very heavy oil.



Figs. 2 to 4. Various Forms of Pistons for Hydraulic Testing Machine

The operation of the machine is as follows: A split die is inserted at *K*, so that it rests on the piston *H*. The die is partly filled with the plastic composition, and a steel plunger is inserted into it at the top. The screw *B* is then run down by means of the crank *L* until it presses on the top of the plunger. A round steel lever is then inserted into the hole *N*, and the screw *B* run down until the pressure desired is registered by the gage *M*. The screw is then run up, and the valve *W* per-

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mits water to enter from a city water main, which causes the piston *H* to rise to the top of hole *R*, thus pushing the die and plunger out of the machine.

When testing, the formed composition (after being treated) is placed on the piston *H* and the screw run down upon it until it cracks. The piston compresses the oil and water so that the pressure at which the test piece cracks is registered by the gage *M*, the valve *W* being closed. The cock *Y* is then opened and the water drains from the machine so that the piston may be pushed back into place. The heavy oil will not pass through the cock. The hand screw *O* and the piston *F* are used when the city water pressure is not sufficient to raise the piston *H*. In this manner the machine both made and tested the formed pieces.

In making experiments with this machine a number of interesting facts were noted which may be useful to persons coming in contact with high-pressure hydraulic work. The pressure used in the experiments varied from 40 to 20,000 pounds per square inch.

The first interesting fact noted was that water worked through the heavy cast-iron walls at about 1800 pounds pressure per square inch, and that it ran through so rapidly at 6000 pounds pressure that it was impossible to increase the gage pressure. Upon the substitution of heavy black oil this leakage was eliminated below 5000 pounds. Upon coating the internal walls with water glass and pressing in the steel bushings, practically all leakage was prevented up to 20,000 pounds per square inch, so long as oil was used. Originally the greatest source of leakage was around the pistons, which were first made as shown in Figs. 2 and 3. These pistons leaked a great deal at 1400 pounds when water was used, and at 2500 pounds when oil was used. Pistons of the type shown in Fig. 4 were then substituted with very satisfactory results up to 16,000 pounds pressure per square inch. This type of piston leaks less after being used for a short time than when first inserted.

* * *

An alloy of iron and cobalt in the proportions of iron from 65 to 70 per cent and cobalt from 30 to 35 per cent is highly magnetic; the magnetism of this alloy at saturation is stated to be 10 per cent greater than that of the pure iron.

CONTENTS OF HORIZONTAL CYLINDRICAL TANKS

By FRANCIS J. FRENCH*

When a cylindrical tank placed in a horizontal position is partly filled with a liquid, the cross-sectional area of the fluid in the tank is, of course, a circular segment. The usual way of calculating the volume of the fluid in the tank would be to find the area of this segment and multiply this area by the length of the tank. In this way, the volume of the fluid would be found in cubic feet or cubic inches, according to the unit of measurement used. This expression, then, would usually have to be converted into gallons.

A rapid approximate method is provided by the accompanying diagram, the use of which is illustrated by an example in dotted lines. The scale on the left-hand side of the diagram gives the ratio of the depth of the fluid in the tank to the total diameter. The diagonal lines on the diagram give, respectively, the diameter of the tank and the total length. The scale on the right-hand side of the diagram gives the volume of the contents in U. S. gallons per foot of length, while the scale at the bottom of the diagram gives the total contents of fluid in the tank.

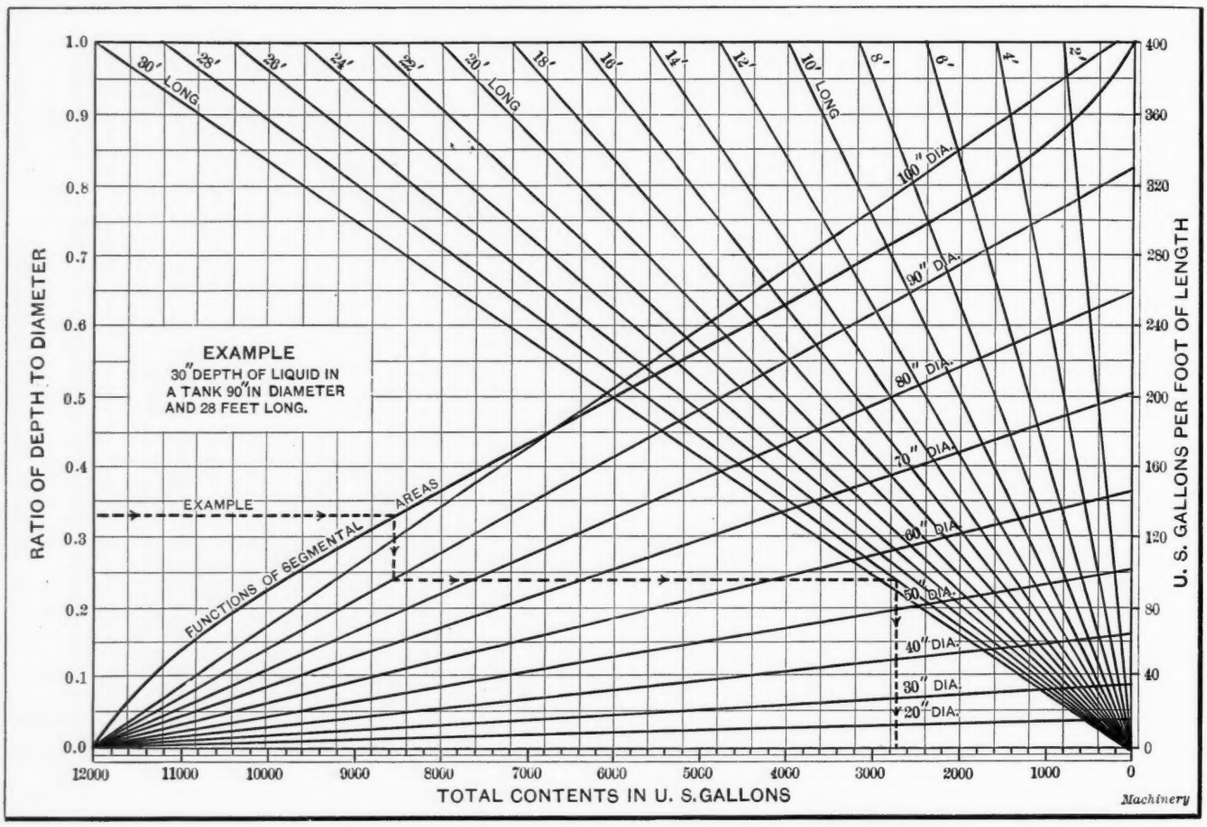

Diagram for Finding the Contents of partly filled Horizontal Cylindrical Tanks

As an example, let us assume that the liquid fills the tank to a depth of 30 inches, that the total diameter of the tank is 90 inches, and that it is 28 feet long. The ratio of depth to diameter is then one-third, and, beginning at this point on the scale to the left, we follow a horizontal line until it intersects the line marked "functions of segmental areas." From this line we follow a vertical line until it intersects the line denoting the diameter of the tank, and then again a horizontal line until it intersects the line for the total length of the tank; from this point we follow a vertical line to the bottom scale which gives the volume of the liquid in U. S. gallons. If from the last point of intersection we had continued following a horizontal line, instead of a vertical line to the bottom scale, we would have located a point on the scale to the right which would have given the volume of liquid per foot of length of tank in U. S. gallons.

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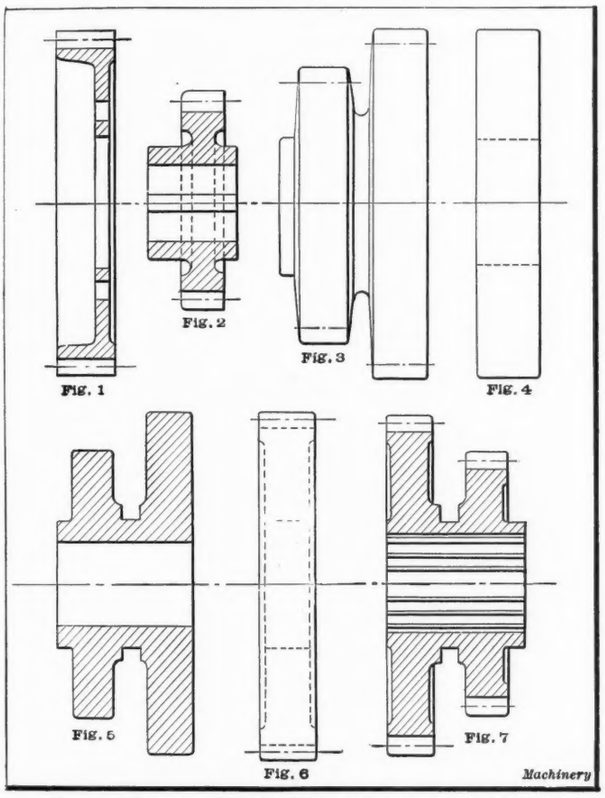
PROCESSES IN PRODUCTION OF AUTOMOBILE TRANSMISSION GEARS*†

One of the most important problems in modern automobile construction, and one which has received a great deal of attention from mechanical engineers during the past few years, is that of the quiet working of the running parts. Next to the engine itself, the gears have proved the greatest offenders in making noise. Therefore, the demand for gears which are accurate, interchangeable and silent, together with the necessity for producing them both rapidly and at a low cost, has caused a great deal of attention to be devoted to the various processes, tools and appliances whereby that demand may be satisfied. We thus find that there are being placed on the market an increasing number of machine tools, steels and carbonizing materials, each of which claims some advantage over its predecessors, such as increased output, greater simplicity, superior generating features, and better hardening results. It is the intention, however, to deal here chiefly with the processes of manufacturing gear-box gears by means of a complete equipment of gages, tools, jigs, etc., with the object of insuring interchangeability. To a very large extent fitting is thus dispensed with. After the final machining operation has been performed, the parts should be ready to be assembled. When a duplicate part is wanted it can be supplied from stock, as the methods here to be described insure that it will fit into its correct position without trouble.



Figs. 1 to 7. Automobile Transmission Gears at Various Stages of Completion

There is probably no part of an automobile that is subjected to greater use—and abuse—than the gears, especially the gear-box gears. Carrying, as they do, practically all the power developed by the engine, and receiving at the hands of a careless driver the strains imparted by suddenly applied load or by rapid changes, it is absolutely necessary that the gears be made of the highest grade materials, and that the very greatest care and the best workmanship should be bestowed upon them. As the saving in weight is an important factor in the design of the transmission, the gears must be made as small and as light as possible, and yet be sufficiently strong to carry suddenly applied loads with no danger of breaking. Owing to the methods by which the speeds are changed, and the clashing and bruising to which the gears are thus subjected, the transmission mechanism must be made of material which is both hard and tough. Different kinds of steel have been used, and each has been treated by various methods in the attempt to discover the perfect gear material. Although this has not yet been found, so much progress has already been made that the transmission gear of a modern well made automobile, when carefully handled, will last nearly as long as the car itself.

Steels used for Automobile Gears

Of the various kinds of steel which have hitherto been employed, nickel, nickel-chrome and chrome-vanadium steels seem to have more advocates than any others. In most factories the gears are casehardened, and it is this class of gear which will be dealt with in the following. Gears treated in this way have been taken out of cars which have been run many thousands of miles, and in some instances the original tool-marks on the face of the teeth were still visible.

The processes in the manufacture of low carbon nickel-steel casehardened gears, such as the finished gears shown by Figs. 1, 2 and 8, will be described in the following. The various processes will be explained in the order in which they are performed. The composition of nickel steel, suitable for high-speed gears, is as follows: Carbon, 0.20 per cent; manganese, 0.65 per cent; silicon, not exceeding 0.20 per cent; phosphorus, not exceeding 0.04 per cent; sulphur, not exceeding 0.04 per cent; and nickel, 3.50 per cent. Steel with 3.50 per cent nickel rolls and forges well, and when hardened, the ratio of the elastic limit to the ultimate strength is very great. The influence of nickel on steel is that it increases the tensile strength and the elastic limit.

Nickel steel of the composition just mentioned should have an elastic limit, after treatment, of about 30 tons per square inch. The influence of silicon on the results of quenching is similar in many ways to that of carbon. It is dependent on the co-existing amount of carbon and manganese, and it is difficult to obtain silicon in steel without the presence of manganese. Silicon appears to increase the tensile strength and diminish the ductility; but for various reasons it is generally considered objectionable.

Phosphorus is the least desirable element in steel, but up to one per cent it appears to increase the tensile strength. Sulphur tends to produce hot-shortness and difficulty in working, but in the presence of manganese the effect is diminished.

The Gear Blanks

Blanks for gears of the type shown in Fig. 1 should be cut from the bar, since it has been proved that steel is not improved by drop forging, although some steels are less sensitive to injury than others. An investigation of drop forged and bar-cut nickel steel gears, details of which were given in a paper read by Mr. John A. Mathews before the Franklin Institute (see MACHINERY, August, 1909, engineering edition, "Alloy Steels for Motor Car Construction"), showed that under static tests the bar-cut gears were fully 25 per cent stronger, and also that the resistance to shock was greater. The gears shown in Fig. 8 should be made from a drop forging, as shown by Fig. 3, although when only small quantities are required, it would not pay to make dies. In this case ordinary forgings should be considered. Gear blanks should be annealed previous to machining.

The reasons for leaving so much extra metal will be explained in the order in which they concern the various operations necessary in the attempt to get a perfect gear—an end which, it is needless to say, is seldom, if ever, attained. In the case of a gear as shown in Fig. 2, made from a bar, it is not necessary, for reasons which will be seen later, to leave any extra metal. Much of the trouble due to distortion in the heat-treatment is caused by the forging operations being done at too low a temperature, in which case the metal does not have a chance to flow properly, but is merely forced into shape by the die. This sets up internal strains that will be released when the part is annealed.

Rough-turning and Annealing

The first operation is to rough-turn the part all over for the purpose of removing the outer skin, previous to the second

* Paper read by Mr. Walter Betterton before the Graduates' Section of the Birmingham (England) Branch of the Institute of Automobile Engineers, April 25, 1912.

† See the following articles previously published in MACHINERY: "Alloy Steels for Motor Car Construction," August, 1909, engineering edition; "Casehardening," August, 1905, engineering edition. See also MACHINERY'S Reference Book No. 63, "Heat Treatment of Steel."

annealing, leaving a one-sixteenth inch case on the parts required to be hardened, such as the top diameter of the gear, and the sides of the teeth. For the bore a one-eighth inch allowance is required, in gears where the hole is to be a running fit, or castellated, and has to be hard. A one-quarter-inch allowance, however, is necessary when the gear has to be bolted to a center, or to another gear, in which case the bore need not be hard, as it is only used for locating the gear centrally. In rough-turning, allowance must be made for the extra metal, the gears, after machining, appearing as shown in Figs. 4 and 5.

When making gears it is, of course, necessary to have the steel carefully and uniformly annealed. The process of annealing is one of great importance, and is better performed in a specially designed sealed furnace, constructed as a muffle, so that the required heat is obtained uniformly by radiation, without any flame to impinge on the steel. In addition to softening the steel, and making it easy to machine, annealing has the effect of bringing it to a more homogeneous condition by eliminating the molecular strains which are set up by rolling, hammering and stamping. Hence, when the steel is heated preparatory to hardening, equal expansion should follow, and also equal contraction when cooled.

It will thus be seen that should the steel not be annealed uniformly throughout, the risks of warping when hardening are considerably increased. The object of rough-machining is to break down the scale preparatory to the second annealing, and as the strains set up by rough-machining are released by the second annealing, the metal is then in as normal a condition as possible. At the present time there are many compounds used for annealing. A few years ago, the ashes from the forge were considered sufficient for properly annealing steel, but today many special preparations are manufactured and sold for the purpose.

The more common materials used are powdered charcoal, charred leather and hydro-carbonated bone-black. These same materials are used for carbonizing, but after having been used once they are of very little use for that purpose. However, their use for annealing has the additional merit of economy, because they can be used repeatedly, adding each time a little that has only been used for the carbonizing process. Air-slacked lime may also be used for this process. The piece to be annealed is usually packed in a wrought-iron box, using one of the previously mentioned materials, or combinations of them, for the packing. The whole is then heated to the proper temperature,which is about 1760 degrees F. In the case of the gears in question, this temperature should be maintained for one hour. The box may then be set aside with the cover on in order to cool down to atmospheric temperature, or it may cool off with the furnace. It should be noted that the annealing temperature ought always to be higher than that for carbonizing. For all kinds of steel and for all grades of annealing, the slow-cooling furnace gives the best results, because the temperature can easily be raised to the right point, kept there as long as necessary, and then regulated to cool down as slowly as desired. Gas, oil, or electric furnaces are, of course, the easiest to regulate.

Finish-boring and Broaching

Gears to be broached as shown in Fig. 8, should be finish-bored with an allowance of 0.015 inch for grinding after hardening, and faced on one end true with the bore to take the thrust of the broaching on a La Pointe or similar broaching machine. The broaches should be made of carbon steel, oil hardened, tempered and ground, and should be specially treated. It is necessary to treat the steel with some carbonaceous material until it will harden in oil, as it is well known that steel hardened in oil is less likely to spring than if hardened in water. The tendency for steel to crack is almost eliminated and it has a maximum of toughness, unless, of course, the steel has been improperly treated in the fire. The special treatment consists essentially in supplying the surface of the steel with an additional amount of carbon by some material that will not injure the steel. No form of bone should be used on tool steel for this process, as bone contains a high percentage of phosphorus, and the effect of this is to make the steel weak and brittle. Charred leather gives the best results.

The over-all length of the broach suitable for the gears shown in Fig. 8 is about 26 inches, the cutting portion being about 17 inches, and the teeth of $\frac{5}{8}$-inch pitch, cut straight and backed off. The pilot should be about 3 inches long. The teeth should never on any account be cut spiral, as this tends to twist the broach while in operation, and consequently the castellation would not be true. To produce an accurate castellated hole, as shown by Fig. 8, in nickel steel, it is necessary to use about ten roughing broaches and one finishing broach, especially when this operation is to be performed to very fine limits, as in the case of the gears in question. The last four teeth in each broach should be parallel, and the rest tapered in equal progression. On the first broach the pilot should be round and of the same diameter as the hole in the gear to be broached. On the following ones the pilot should be a sliding fit in the hole produced by the previous broach, and should at the same time be located from the castellations.

The finishing broach should have a piece at the rear end, about 3 inches long, of the exact size of the castellated shaft on which the gear is to be fitted when finished. This will act as a burnisher. The broaches are pulled through the work, which is quite a good feature, as it tends to keep them straight while in operation. The cutting portion being so long enables the operation to be performed without previous rough-slotting, which is required when the gears are drifted on the power press. After broaching, the gears should be turned.

Finish-turning

Castellated gears should be turned on a mandrel, locating from the castellations. The parts required to be hard, such as the top diameter of the gears, which should have an allowance of 0.005 inch for gear-cutting purposes, and the sides of the teeth and fork groove are then finished, leaving the gear as shown in Fig. 5. In the case of the gear in Fig. 1, the top diameter should be finish-turned with an allowance of 0.005 inch, and the sides of the teeth and the bore with an allowance of 0.125 inch, so that the latter can be bored out again after carbonizing, which would leave the hole soft, as it is not required to be hard. The finish-turning leaves the gear as shown in Fig. 4. Gears such as shown in Fig. 2 can be finish-turned and bored complete at this operation.

Cutting the Teeth

One of the most important operations is the cutting of the teeth after annealing. The method to be described is at present in practice and gives very successful results. The teeth should be roughed out on the hobbing machine and, where possible, several gears should be placed on the work-arbor at one setting. A great deal of time is saved by placing several gears on the work-arbor, which should always be steadied at the top. Suppose six are to be cut at one setting; this would mean that the hob would only have to travel into and clear the work once instead of six times, which would be necessary if they were cut singly. When putting several gears on the arbor, they must be faced exceedingly true, or the arbor will be bent. This is especially true when the hole is small and the gears large in diameter. Plenty of lubricant should be applied in this operation, oil being most commonly used. The hob should be made of high-speed steel, a six-pitch hob being 3 inches in diameter, and a five-pitch hob, $3\frac{1}{2}$ inches in diameter. On account of the accuracy required, single-threaded hobs are preferable. For the roughing operation a cutting speed of sixty feet per minute of the hob, and 0.020 inch feed per revolution, are considered good practice for a nickel steel six-pitch gear.

For the finishing operation at least 0.010 inch should be allowed for a six-pitch gear and other pitches in proportion. If the finishing cut is merely a scraping cut and not enough stock is removed to let the cutter get a real chip, the cutter may glaze over the work, especially if the cutter and the work-arbor are not held rigidly. The gears should be finished one at a time, excepting plate gears, in which case several can be placed on the arbor at one setting. For this purpose a Fellows gear shaper should be used, because the cutter can be made far more accurate than a hob or a rotary cutter. The teeth of this cutter can be ground after hardening, and this

corrects any inaccuracies that may have crept in. On the cutter-arbor, at the back of the gear-cutter, should be placed a round disk made of high-speed steel, hardened, ground and backed off, which will act as a shaving tool and will take off the 0.005 inch left on the top diameter, as previously stated. This will make the outside diameter true with the pitch line. The teeth should be cut about 0.001 inch thin at the pitch line to produce a running fit. The gears should now be tested for center distance, for which purpose a plate with two pins for the bores, set at the correct center distance, should be used.

Owing to the courtesy of Mr. Ward, of the Universal Gear Grinding Co., the author has had the opportunity of seeing in

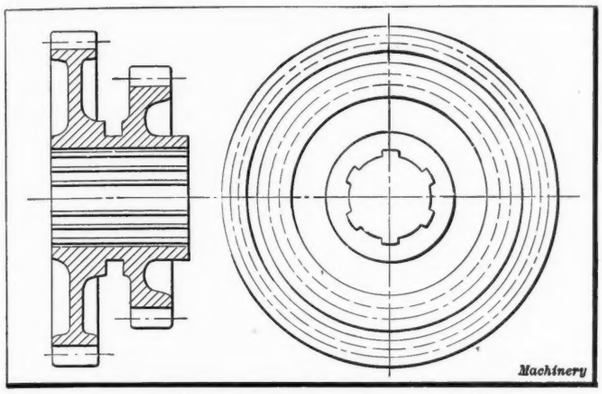


Fig. 8. Completed Gear, shown in Progress of Evolution in Figs. 3, 5 and 7

operation a machine for grinding gear teeth, which has the appearance of filling a long-felt want in the automobile industry. If it is—and the author believes it is—what the makers claim for it, it would not be necessary to finish-cut the teeth, as, with the exception of those of the gear shown in Fig. 8, they could be ground after hardening. This would obviate the final process of "grinding-in" with emery and oil, a process which at present is so unsatisfactory. In the case of the gear teeth shown in Fig. 8, the grinding wheel would foul the large gear when grinding the small one, to overcome which it would be necessary to re-design the gear and make it in two parts. The machine has many good features, the main one being that the shape of the wheel is maintained by three diamonds which dress the wheel, and which are controlled by one former. One is used for truing up the top diameter of the wheel, and one is placed on each side for truing the curvature.

The tooth-rounding should be performed on an automatic tooth-rounding machine. Several gears should be mounted on the same arbor, and the teeth of the wheels may be rounded in succession at one setting. No doubt most readers are quite familiar with the reason for this operation, which, therefore, requires little explanation, unless it be to say that it is done to facilitate the changing of the gears, and also to prevent the teeth from being chipped when engaging, which would occur if the corners were left square. The sides of the teeth which are not rounded should be fraised before carbonizing, which is the next operation.

The Carbonizing Process

In carbonizing, great care should be taken, as, to a very great extent, the life of the gear depends on this process. The result of the process is determined by four factors, namely: the nature of the steel; the nature of the carbonizing materials; the temperature of the carbonizing furnace; and the time taken by the process. The carbonizers in general use at the present time are animal charcoal, hydro-carbonated bone-black, charred leather, and a few other compositions sold under various names. Owing to the various conditions under which the operation is carried out, experience must largely guide the operator. Theoretically, the perfect carbonizer should be a simple form of carbon, and charred leather gives very satisfactory results. Care should be taken to avoid poorly charred leather, or that made from old boots, belting, etc. Good charred leather should contain about 88 per cent of carbonizing matter.

As it is essential that the core of the gears should be left soft in order to withstand the high speed and sudden shocks to which they are subjected, the carbon content in the core should be low. For this reason preference is given to 0.20 per cent carbon steel. The carbonizing pots are made from both cast and wrought iron; the former are cheaper in first cost, but the latter bear reheating so many times that they are really cheaper in the end. The carbonizer having been thoroughly dried and reduced to a fine powder, a layer of not less than 1½ inch in depth is placed in the carbonizing pot and well pressed down. Upon this, are placed the articles to be treated. Care must be taken to have sufficient space all around each piece so as to prevent them from touching each other or the walls of the pot. About 1½ inch is sufficient. Another layer of carbonizing material is then put in and well pressed down, care being taken not to displace any of the gears. The process is then continued until the pot is full, finishing with a layer of about 1½ inch at the top.

The object in view is to make the contents of the pot as compact as possible, consistent with a sufficiency of carbonizer in contact with the gears. The more solidly the pot is packed, the more complete the exclusion of air. The lid is then put on, and the joint all round luted with clay. The pot should be placed in a furnace similar to that used for annealing, and heated to about 1700 degrees F., which heat should be maintained constant for from six to ten hours. The length of time occupied is regulated by the depth of casing required, which

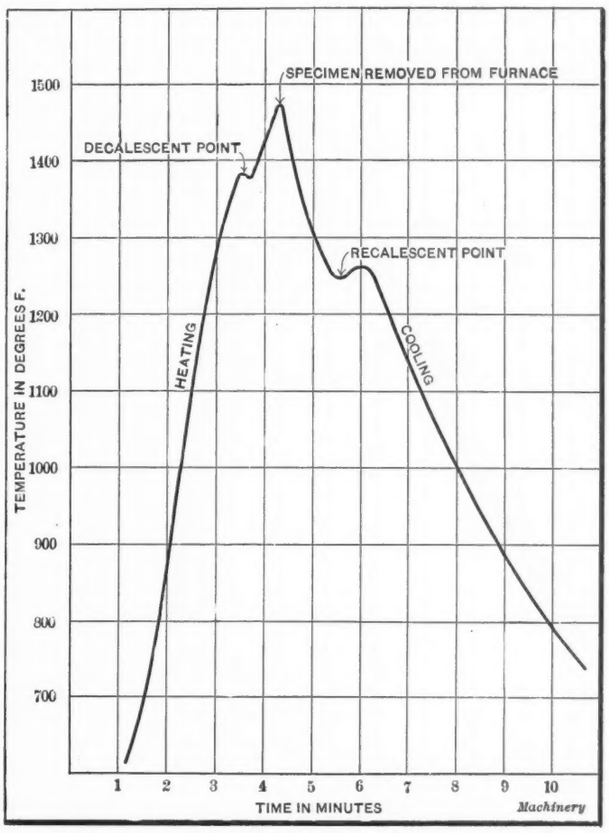


Fig. 9. Curve showing the Decalescent and Recalescent Points for Low Carbon Nickel Steel

should be about three-sixty-fourths inch, and also by the dimensions of the gears. At the close of the carbonizing period, the pot is withdrawn and put in a dry place where it is allowed to cool to atmospheric temperature. It is then opened, the articles are taken out, and the process is completed by brushing to remove all adhering matter.

It may be noted here that the case should only be deep enough to resist wear and battering. If the case is so deep as to form a considerable part of the cross-section of the teeth, the teeth may break unless the case is considerably tempered.

Turning Operations Preceding Hardening

The next operation is to turn out the carbon from the parts required to be soft. In the case of the plate gear shown in Fig. 1, which is to be bolted to another gear or center, as

previously stated, the hole need not be hard. For this reason, it was left with an allowance of ⅛ inch at the previous turning operation. It should now be bored with an allowance of 0.015 inch for grinding after hardening, and faced down on both sides. This refers to both plate and castellated gears as shown in Figs. 6 and 7. The boring operations should be performed while the gear is held in a collet-chuck, locating from the top of the teeth, which were trued up with the pitch line by the shaving tool used when cutting the teeth, as previously explained. This method has been found to be more efficient than locating with balls or rollers on the pitch line. The penetration of carbon being only about three-sixty-fourths inch it is now removed from the parts which have just been turned. Consequently these parts will not be hardened. The excess metal is left as shown in Figs. 6 and 7 until after hardening, in order to prevent warping, which would undoubtedly happen if the gears were finished as shown by Figs. 1 and 8.

The Casehardening and Oil Tempering

Steel of the composition mentioned can be hardened as follows: Heat from 1450 to 1525 degrees F. and quench in water; re-heat to about 1400 to 1450 degrees F., and quench in water. The re-heating must be conducted at the lowest possible temperature at which the steel will harden. It will be found that this is sometimes as low as 1300 degrees F. Then, as a safeguard, re-heat to a temperature of between 250 and 500 degrees F., in accordance with the requirements of the case, and cool slowly in oil. Parts of intricate shape, such as the gears dealt with, having sudden changes of thickness, sharp corners and the like, should always be tempered or drawn in order to relieve internal strains.

Another method of procedure is as follows: Heat from 1450 to 1525 degrees F., and quench in hot brine. Re-heat from 1450 to 1525 degrees F., and quench in oil. The temperature need not be drawn when the gears are quenched in oil. The final quenching should be done at the lowest temperature at which the piece will harden, as stated in the first method.

A small gas muffle should be used for hardening. A properly constructed gas muffle can be regulated with the greatest nicety, and in hardening this is most important. When steel is gradually heated, there is a certain point at which a great molecular change takes place, and perfect hardness can only be obtained by quenching at this critical point. This would lie between 1300 and 1450 degrees F. When steel is cooled, whether slowly or not, it bears in its structure a condition representative of the highest temperature to which it was last subjected. From this it will be quite clear that in casehardening, as in all methods of hardening, the steel must be quenched on a rising heat. Steel which is overheated previous to the final quenching, is very brittle and liable to fracture easily, and although quenched and subsequently hardened, the metal has little or no cohesion, and rapidly wears away. Steel so hardened breaks with a very coarse crystalline fracture, in which the limits of the case are badly defined. If quenching takes place below the critical point previously mentioned, the steel is not sufficiently hard. If above, though full hardness may be obtained, strength and tenacity are lost, in part or completely, according to the degree of heat by which the critical temperature is exceeded.

It may be asked why it is not sufficient, when the pieces are heated at the first re-heating to about 1500 degrees F., to place them in another furnace and reduce to the critical temperature and quench, instead of quenching twice. The answer is that the high temperature has already created a coarse crystalline condition in the steel, and that, until it has been cooled down below the critical point, and re-heated to the critical temperature, a suitable molecular condition cannot be obtained.

As a further means of illustrating what is meant by the critical point, Fig. 9 shows a curve plotted from results obtained by a recording pyrometer, in which the decalescent and recalescent, or critical points are shown. From this it will be seen that the absorption of heat occurred at about 1375 degrees F. on the rising temperature; and the evolution of heat at 1250 degrees F. on the falling temperature which was allowed to fall slowly. The relation of these critical points to hardening is that it cannot take place unless a temperature sufficient to produce the first action is reached in order to change the pearlite carbon to hardening carbon; and also unless it is cooled with sufficient rapidity to eliminate the second action. The temperature would, of course, be gaged with a pyrometer.

Sandblasting

The sandblasting, which serves to scour off any roughness or stains which have been left on the surface during the heat-treatment, etc., is best conducted in a building separated from the remainder of the shop. The sand should be kept in a bin in one corner, and sucked up by a centrifugal blower and forced by air pressure through a blow pipe which terminates in a nozzle. The sand being forced by the air at a high velocity, may be directed at all parts of the piece to be cleaned. This is one of the most efficient methods of polishing and cleaning the gears, and does not injure the hard surface in any way.

Hardness Testing

The gears should now be tested for hardness. The scleroscope appears to be the best instrument for doing this. If a gear shows a considerable drop in hardness, a file should be used to determine whether the cause is due to the piece not being hard, or to crystalization. If the parts can be scratched with a file, it shows that it is not hard enough. If, however, the file will not bite on the spot where the scleroscope reads low, then it is positively known that it has been overheated and is crystalized. A good method of testing the teeth is the drop test. By this method a ten-pound weight with a 56-inch drop is directed at one tooth. The number of blows necessary to break the tooth should be noted. This test would only be applied occasionally, say, on one out of each batch of gears. A gear which has given satisfaction should be tested, and the result used as a standard for future comparison.

Final Turning Operations—Grinding

The metal left for supporting the gears while undergoing heat-treatment is now removed. This operation should be carried out with the gear held in a collet-chuck, and care should be taken that the outside diameter runs true before starting. The hole having been bored after carbonizing, is now soft. The metal can be turned out on both sides, or on one side, as the case may be, leaving 0.005 inch on the face of the web for grinding. This operation should come next, and is most essential in order to get a true running gear when in position. The castellated gears which were finish-bored with an allowance of 0.015 inch before carbonizing are now hard, this being necessary as they have to be a sliding fit on the shaft. The part of the bore which bears against the lands of the castellated shaft is all that can be ground. Unfortunately no method has yet been devised for grinding the castellations themselves, and these, therefore, have to be lapped separately by hand—which is most unsatisfactory. While grinding the bore, the gear should be held in a collet-chuck from the top diameter—hence the truing of the top diameter with the pitch line in the gear-cutting process. Gears ground in this way should be perfectly true, and are now ready to be tested for center distance and true running.

The Drilling

It should be clearly understood that the web of the gear shown in Fig. 1 is now soft. This brings us to the final machining operation, that is, the drilling. There are many advantages gained in leaving this operation until the last. The bore is now the correct size, this being essential for locating the drilling jig. Furthermore, in the grinding operation, the bore is totally ignored, the top diameter being the most important. The hole has been ground true with the latter, so that if the holes had been drilled previous to the hardening, they would not be concentric with the bore, and would not match with the gear or center to which it has to be bolted. Another advantage is that the holes are now soft and can be reamed with the piece to which the gear is to be bolted, it being understood that these would also be left soft in the parts in which the holes are required. All these are important points, and this is the reason for leaving the drilling until last.

The "Running-in"

The gears should now be bolted to their respective parts and finally "run in" before being placed in the car. This should

be performed in a special case, and the "running-in" done under belt power. The bearings, in these special cases, are set at the proper center distance, so as to accommodate the various gears of a train, thus wearing in the gears so that all those for similar parts are absolutely interchangeable. The case is made oil-tight, and a mixture of finely powdered emery and lubricating oil is forced through an opening in the top, so that this grinding material will come in contact with all the teeth in mesh in the train. The grinding is continued until each tooth has been worn perfectly smooth, and to an accurate fit with the teeth of the other gears with which it comes into mesh. As a further means of thoroughly running in the gears of the transmission to a perfect fit, the motor, transmission and driving shaft are installed in the chassis, and the motor is run while the various speeds of the transmission are thrown into mesh. During this run an electric dynamoter, by means of which a variable load may be applied, is connected to the end of the driving shaft. The gears should now be as perfect as, with the best practice yet known, it is possible to get them.

It may be objected here that the leaving of extra metal for heat-treatment is rather costly. This is a question upon which there is room for a considerable difference of opinion. The author is of the opinion that if the method of leaving extra metal is used with discretion, and only in the case of very intricate gears, the most satisfactory results should be produced.

* * *

VANADIUM IN HIGH-SPEED STEEL

When high-speed steel was first alloyed with vanadium the vanadium was used in no greater amounts than 0.2 to 0.3 per cent, but it has been found that greater percentages produce better results, and as much as 0.75 to 1 per cent is now generally used. The efficiency of a tool may be measured either by the cutting speed at which the tool will last for a specified time, or by the length of time it will last under the same speed and general conditions without resharpening. Tests have shown that a tool steel containing 0.3 per cent of vanadium will stand up under a ten per cent increase in speed as compared with the same steel containing no vanadium. If 0.6 per cent of vanadium is added, an increase of twenty per cent in the speed is possible, and with 0.9 per cent of vanadium the speed may be increased thirty per cent. As regards the effect on the time between grindings, the speed and other conditions being the same, 0.3 per cent vanadium in the steel doubles the time between grindings, 0.6 per cent quadruples the time, and 0.9 per cent octuples it, eight times as much metal being removed between grindings, if the same speed and feed are used as would be efficient with the same steel containing no vanadium. These figures are given in a recent publication issued by the American Vanadium Co., Pittsburg, Pa.

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TOO MANY SPEED CHANGES NOT AN ADVANTAGE

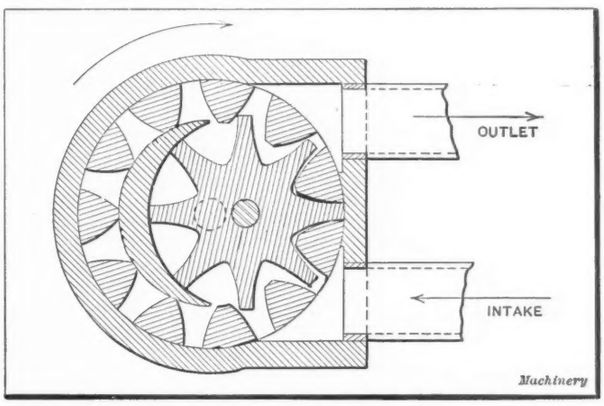
In an article on "Rational Machine Tool Design," by Prof. J. T. Nicolson, published in the *Machine Tool Engineer*, a supplement to the *Practical Engineer* (London), the author states with great emphasis that "the modern craze for large numbers of spindle speeds is not warranted by considerations of commercial economy; and it is to be distinctly condemned from the point of view of technical efficiency. The fewer the number of speeds, the broader, stronger, and more durable can be the gears, the smaller will be the power wasted in friction and the more compact and handy may be the headstock" of a machine tool. He says, further, that there is no money for the user, in a headstock with a large number of spindle speeds, and, even if there were, it is very doubtful whether the operator would use the speed changes intelligently. The added complication is a source of trouble in the working of the machine. A simple headstock with from eight to ten speeds, is, according to Prof. Nicolson, the best for every requirement. The great secret of economical cutting is not a complex headstock with many spindle speeds, but a lathe of moderately simple design which is kept constantly at work.

THE VIKING ROTARY PUMP

The accompanying illustration shows the principles of an interesting rotary pump, invented by Mr. Jens Nielsen of Cedar Falls, Iowa, which has recently been tested at the Engineering Experiment Station of the Iowa State College, and is described in the April number of the *Iowa Engineer*.

As will be seen in the illustration, the pump has but two moving parts—an outside annular gear, and an inside spur gear. The large gear has a shaft at the back which extends through the pump casing and carries the driving pulley. The spur gear is mounted on a stud extending from the opposite side of the casing, which also has a crescent shaped projection on one side, dividing the space between the two gears as shown. While, in the illustration, the lower pipe is shown as the intake pipe and the upper pipe as the outlet, either may be used for the intake, depending upon the direction of rotation. The action of the pump is evident. After the water enters the pump, it is carried around the pockets formed by the teeth in the large gear and the crescent-shaped projection. When the gears come into mesh on the upper side, all water is forced into the outlet port.

Tests have been made with heads varying from 30 to 150 feet of water and at speeds from 200 to 450 R. P. M. At 215 R. P. M., the efficiency was 48.6 per cent. At 400 R. P. M.,



Diagrammatical Section of the Viking Rotary Pump

the efficiency was 76.3 per cent. The average efficiency of all the tests was 64.8 per cent, the average speed being 360 R. P. M. At high velocities, the average efficiency was practically 70 per cent.

The comparatively positive action of the pump is shown by the discharge per revolution. At the lowest efficiency this discharge was 0.209 gallon, and at the highest, 0.235 gallon, which shows that even at the lowest efficiency the leakage was slight. The volume of water discharged per revolution, if there were no leakage, would be 0.259 gallon.

One advantage of the pump is that only one moving part requires packing—the main shaft where it enters through the back casing. The inventor has used one of these pumps in a stone quarry since 1906 pumping water mixed with mud and fine gravel. This pump is still working satisfactorily.

* * *

An interesting departure in advertising has been made by the American Woodworking Machinery Co., Rochester, N. Y., in a recent issue of *Vocational Education*. This firm offers to give, free, with a stereopticon, a series of slides showing in detail the construction of its No. 77 fast feed planer and matcher, from the foundry to the testing floor. The details which accompany each slide enable a teacher to prepare a talk before his class in connection with the exhibition of the views. What better method is there to acquaint a class in machine shop practice, for instance, with the mechanism and process of construction of a machine, than by showing the actual work? This, of course, can best be seen in the shops but if that is not practicable, the next best method is to show pictures of the operations. These few slides will convey more information on woodworking machinery to a class than pages of written matter or hours of unillustrated oral explanation. The value to the advertiser who thus makes known his tools is obvious.

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MACHINERY

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We solicit contributions from practical men on subjects pertaining to machine shop practice and machine design. All contributed matter published exclusively in MACHINERY is paid for at our regular space rates unless other terms are agreed on.

JULY, 1912

PAID CIRCULATION FOR JUNE, 1912, 24,674 COPIES

MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition, $1.00 a year, which comprises approximately 700 reading pages. The Engineering Edition—$2.00 a year, coated paper, $2.50—contains all the matter in the Shop Edition, about 300 pages a year of additional matter and forty-eight 6 x 9 Data Sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. The Railway Edition, $2.00 a year, is a special edition, including a variety of matter for railway shop work—same size as Engineering and same number of Data Sheets.

NOVELTY IN PATENTS

The communication from Mr. Shaw in another part of this number regarding an application of ball bearings to machine tools, raises an interesting question as to what constitutes novelty in patents. The requirements of construction for a drilling machine spindle as regards bearings are that thrust in the direction of the spindle shall be supported as well as the lateral thrusts due to belt pull and other forces acting against the sides of the spindle. This means that in the simplest form of spindle bearing, as ordinarily made, there shall be two radial bearings and two thrust bearings. Two thrust bearings must be provided, one to take the thrust of drilling, and the other to carry the weight of the spindle when not at work.

The designer of the drilling machine referred to by Mr. Shaw, took up the problem from a new point of view, however, and succeeded in providing a successful ball bearing construction consisting of two radial bearings only. The novelty lies in the elimination of separate thrust bearings by following a perfectly logical assumption. Radial bearings of the well-known annular types are rated as having a thrust bearing capacity of twenty-five per cent of the allowable radial load. Hence the requirements of drilling machine spindle bearings are perfectly satisfied by providing two radial bearings, one of which has a radial bearing capacity of at least four times the thrust bearing requirement. Suppose the maximum thrust to be provided for is 1000 pounds, then a bearing capable of carrying a radial load of 4000 pounds will safely carry the thrust load and, of course, be far above the lateral thrust requirements.

The question is: Does this design, embodying a simple construction found in hundreds of other machines not required to provide for endway thrusts on shafts but which in this case provides for thrusts by greatly increasing the radial bearing factor, constitute novelty? We believe that it does, and that the lucky discoverer of the principle is entitled to all the protection provided under patent laws. The best ideas are generally the simplest, and in this case machine construction has doubtless been improved and simplified at one stroke. This is the height of machine design accomplishment.

* * *

VALUE IN A GOOD NAME

A bill has been introduced in Congress providing that all products intended for interstate or foreign trade shall be stamped with the name and address of the makers. The penalty provided for violation of the proposed statute is a fine of one thousand dollars or imprisonment for six months, or both. The same penalty is provided for erasing or changing the stamp.

It is practically impossible to frame any drastic law that will not work hardship or injustice to a few, and probably this proposed legislation is no exception; but we believe that in the end it would confer material benefits on both manufacturers and consumers. A great step forward would be made for honesty in manufacturing and selling, and dishonest competition would be hard hit.

Every machine tool that carries the maker's name is not only a permanent advertisement for him, but an incentive to produce his best, and security that others shall not appropriate the prestige acquired through honest workmanship and effective design. There can be no objection to a dealer attaching his nameplates to machines sold; but we believe that the policy followed by some dealers of replacing the name of the manufacturer with their own is bad for the industry, because it relieves the maker of all responsibility for the character of his product and places a premium on poor workmanship. A good name and an established reputation are of the greatest help in selling machine tools, and the most successful dealers represent manufacturers who possess them. Their dealers can talk *quality*—the men who are selling tools without any reputation can only talk *price*.

* * *

FIXING RESALE PRICES

Many manufacturers fix the prices at which their products are sold by means of agreements as to resale prices, and by employing the principle of constructive infringement in the case of patented articles. Fixing resale prices has many advantages. The practice enables the manufacturer to advertise a product and the price, and to insure to the retailer a reasonable profit. It secures the retailer's position and prevents unfair competition so ruinous to the trade. Probably one of the most wholesome developments of the past twenty years of American trade has been the establishment of fair resale prices and the elimination of destructive competition.

But the principle of constructive patent infringement, of comparatively recent development, may be used for other purposes than the fixing of fair prices which insure reasonable profit to the retailer. Constructive patent infringement may be used as the means by which monopolistic control of manufactured products can be secured by groups of allied manufacturers. House bill 23417 has been drawn with the view of eliminating the danger arising from the power of the owners of patents to monopolize any manufacturing field, and this bill, it is hoped, will prevent patentees or owners of patents from attaching to the sale of goods unreasonable restrictions as to prices or methods of sale.

The matter of establishing resale prices presents many difficult and conflicting propositions. No one can deny that it is better for the manufacturer, jobber, retailer and consumer to have stable prices. Fluctuating prices mean uncertainty and demoralization. Fixed prices may insure a fair profit to all concerned in the distribution of the goods. The purchaser buys with the feeling that he is paying the market price and no more, and that he must pay the fixed price wherever he purchases the article. On the other hand fixed retail prices may enable groups of manufacturers to eliminate the law of supply and demand and impose monopolistic conditions which are intolerable.

We believe that whatever solution is found the result should not depend upon the provisions of the patent law, for that should not be used to enforce conditions of sale or use. The law should only secure to the inventor a reasonable reward for his ingenuity and labor.

WHAT TO STUDY

Sometimes we receive letters from young mechanics, saying, in substance: "I am a young man employed at the ——— Works, and I want you to recommend some books that I ought to study." The editor who must answer a question of that kind is in a worse plight than the doctor who is required to prescribe for a disease that he cannot diagnose; for the doctor can usually prescribe something harmless and "get away with it," but the editor cannot proceed along such easy lines. He is expected to give good, practical advice with but an indefinite knowledge of the needs of a young man whom he has never seen, and with whose previous education, ambitions and mental capacity, he is not familiar.

Some men should be advised to study anything and everything that would be useful to them in an executive position; while to others such advice, if followed, would mean simply disappointment and waste of time and effort. Some men do not possess the peculiar qualities that would enable them ever to rise to high executive positions; and those men should rather concentrate all their educational effort on practical study of the kind of work they are engaged on, so as to become proficient in that. Others, again, of a more energetic, more resourceful, or a more brilliant make-up, should pursue studies along entirely different lines—studies which may not benefit them within a year or two—perhaps not within five years; but which would ultimately prove useful to them when in positions of an entirely different character from those which they now occupy.

What a man should study is largely a question which he must decide for himself. It is difficult for anybody else to decide it for him. A man should increase his knowledge of the work in which he is most interested—it will make both his work and study easier. For example, if he is interested in drawing, and has a natural ability for working out ideas or designs of his own, we advise him to study drafting, machine design, mechanics and mathematics, so as to utilize his natural inclinations. The young man whose sole interest is centered upon the practical operations in the shop, different methods of grinding tools to obtain the best results, short cuts for obtaining increased production, etc., we advise to pursue studies along shop practice lines, because for him the shop proper undoubtedly offers the greatest possibilities. If he is familiar with shop practice and has acquired a knowledge of the use of the various machine tools and shop systems, and, in addition, has a personality which makes him capable of handling men, there is no reason why he should not rise to be a foreman or superintendent.

In choosing a course for study, however, do not be misled by the idea that immediate benefit will be derived from it. Many a man who has risen to a prominent position in the industrial field has spent years in studying subjects which have been of no immediate advantage to him. It may have been five or perhaps ten years, before he has found a direct application for his knowledge; but he would have been unable to fill the higher position satisfactorily had he not acquired a fund of knowledge during the years when he had the opportunity.

Fig. 1. One of the Drafting-rooms. All Work is designed here and Working Drawings are made for the Pattern and Machine Shop

Fig. 2. Wood-working and Pattern Shop equipped with the Latest Machinery and Tools for this Class of Work

THE WENTWORTH INSTITUTE*

A TRADE SCHOOL FOR TRAINING SHOP-FOREMEN AND SUPERIOR WORKMEN

By CHARLES L. HUBBARD†

A day spent at the Wentworth Institute, Boston's new school for industrial training, described in the October, 1911, number of MACHINERY, so impressed the writer with the value of the methods employed and the results obtained in training foremen and skilled mechanics, that he believes some of the enthusiasm absorbed from this group of busy men and boys should be passed along so that others may profit by it. What is so important to the efficiency of the shop as a whole, and to the advancement of workmen individually, as enthusiasm? Let the young man of average ability become sufficiently filled with love and respect for his chosen work and appreciation of the principles that underlie it, and the other requisites for success will follow naturally.

The Wentworth Institute is giving its students just this kind of a start, not by way of advice, but in a practical way, which not only makes a greater immediate impression, but is far more lasting. The object of this article is to describe briefly the general scheme followed in bringing about this result, in the hope that it may be developed in other schools of similar character, and also that it may awaken greater interest in practical industrial education, both among mechanics and among manufacturers and employers of skilled labor.

A casual inspection of the catalogue of this institution fails to show any particular difference from the methods followed in other trade schools, but as soon as one steps inside the building, he catches the air of the genuine earnestness, efficiency, and system noticeable in the business and engineering offices of the highly organized concerns of the present day. Furthermore, the impression is lasting as one passes through the different departments and notes the interest and industry of the students in their work, their businesslike, intelligent and skillful way of attacking their tasks and overcoming their difficulties, and the complete absence of any action which would tend to detract from the seriousness of the work in hand.

The average boy leaves school at fifteen or sixteen years of age. He enters a shop as an apprentice under the usual conditions, has little to encourage him during his hours of work, and too often little to look forward to in the future. He is placed at some task where he will be of most value to his employer, with scant regard to his own advantage in the way of learning his trade. A desire on his part to find

* The following articles on industrial schools, trade education and kindred subjects have previously been published in MACHINERY: "Features of Apprenticeship System at the General Electric Co.'s Lynn Works," April, 1912, engineering edition; "The Cincinnati Method of Industrial Education—A Friendly Criticism," March, 1912, engineering edition; "The Wentworth Institute," October, 1911; "T. R. Almond Mfg. Co.'s Evening School," July, 1911; "Training of Machinists in the Trade School," July, 1911, engineering edition. See also other information previously published, referred to in connection with the last-mentioned article.

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out the reason for doing things is not encouraged, and those above him have not time for answering questions. It is not the fault of the foreman; he is held responsible for turning out the greatest possible quantity of work with the men in his charge. The fault is really with the system, and to remedy this fault, schools like the "Wentworth" are being established. Mr. Dodge, past president of the American Society of Mechanical Engineers, in speaking upon this subject, says: "The apprentice boy who picks up a trade, learning it chiefly by imitation and with little or no instruction, enters a machine or wood-working shop at sixteen and earns

Fig. 3. Foundry in which the Men are trained to become Skilled Workmen and Foremen

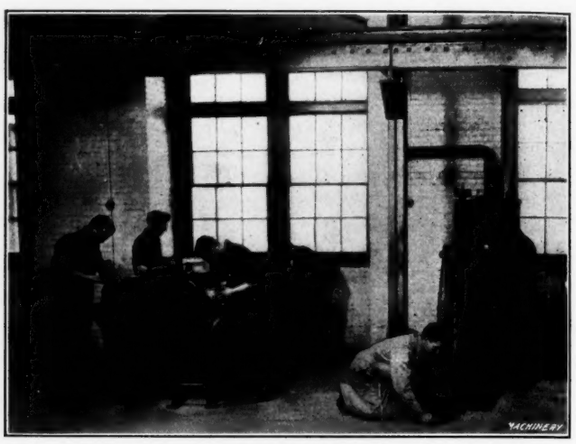

Fig. 4. Light and Spacious Core Department located on the Balcony in the Foundry

an average wage of $3.00 per week. At twenty-two years he may be earning $13.50, but at twenty-four years he has reached his highest earning capacity, getting $15.80 per week."

What is there to give a young man enthusiasm and draw out the best there is in him under such conditions? There may be a few special cases where young men have sufficient ability and endurance to win out under any condition, but the larger part usually drift from shop to shop, gradually losing hope of better things, and develop into "one-machine" men with practically no chance of further advancement. These statements are not intended to discourage men who are working under these conditions, but rather to encourage them by pointing out the opportunities that are open to them through the development of modern trade schools. Europe has long been aware of the advantages of this method of instruction, while America is only waking up to its possibilities. This is shown by an item which appeared in a recent number of the *Outlook*, and which states that in 1908 Prussia had 400,000 pupils, or nearly 14 per cent of its entire population, enrolled in its industrial schools, while only 2 per cent of the population of the United States were being trained in a similar manner. In some of the best shops, it is true, more care is taken in training apprentices than in others, and in certain cases private trade schools are now being carried on for the purpose of supplementing the training of the apprentices in the shop; but admirable as are some of these efforts to give the apprentice boys a chance, their number is still so small—and is certain to remain small in proportion to the demand—that there is genuine need for the public trade school in every industrial center.

It has already been stated that one of the prime objects always kept in view in the training at the Wentworth Institute is to awaken in the student a thorough and lasting interest in his work. This is done, in a very simple and practical manner, largely by answering questions, both *asked* and *unasked*, and this really covers the whole field of teaching. Answering unasked questions gradually trains the student to ask them on his own account, and as his reasoning powers are developed, he reaches a point where he answers some of them himself. Now, when a man can both ask and answer his own questions he becomes original, and furthermore, an original man has ideas. Given a man with originality, and a training to properly discriminate between the practical and impractical, and he will neither lack interest in his work nor have a long wait for success. Such men are in demand in all the manufacturing plants of the country at wages that are only limited by their ability.

One or two illustrations will serve to show the general methods followed in accomplishing this result. For example,

Fig. 5. A Student engaged in Pattern Making, which forms a Part of the Shop Course in General Machine Construction

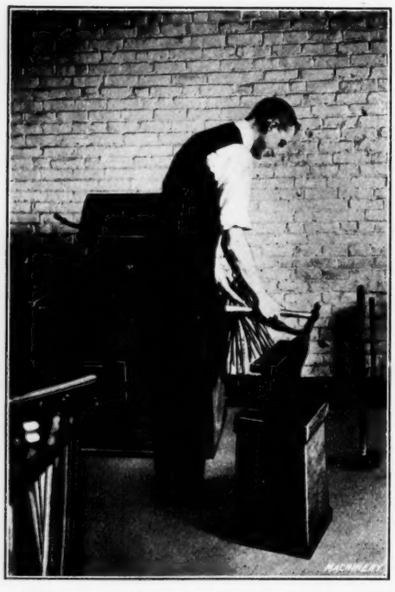

Fig 6. A Student at Work in the Forge Shop, a Course in Forging also being included in the General Shop Course

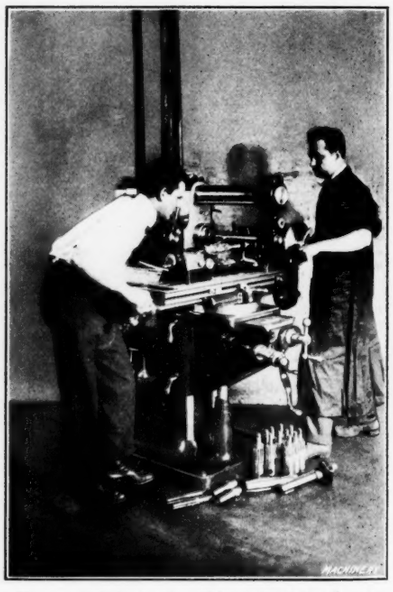

Fig. 7. Work in the Milling Machine Department, illustrating the Character of the Work being done

a student is given a piece of work to be done on a lathe. His instruction is not confined to this piece of work alone, but he also makes a study of the lathe itself. Every part which goes to make up this machine is examined, and its use and the principle upon which it operates, are carefully explained. He is taught to make computations in gearing so that the necessary changes for screw cutting, etc., may be made without the use of tables. Tests are made upon the strength and friction of gears, belts, lubrication, etc., until

Fig. 8. General View in the Forge Shop

he has thoroughly mastered the machine itself, and has become proficient in its use. This same general scheme is carried out in a similar way upon all of the various machines in the shop. Thus the student not only becomes familiar with the use of machine tools, but is also able to detect and correct faults in their operation, and make proper adjustments. All of this forms a part of the necessary qualifica-

Fig. 9. General View in the Machine Shop

tions of a foreman, and adds greatly to the chances of future promotion.

Various methods are employed for awakening and holding the ambition of the student besides the regular routine work. One scheme is to incite a friendly spirit of competition in the several departments, which is illustrated by the following incident connected with the foundry practice. One feature of this course is to learn the art of shoveling sand properly, which, of itself, is not an especially interesting operation. To add zest to this exercise, and awaken a suitable amount of interest, and to test the mettle of the men, the class was divided into gangs working in competition, both as to speed and quality of work done. To avoid monotony, this work was carried on in connection with subjects requiring equal time in the class rooms, drawing rooms or laboratories, so that each type of work seemed by contrast a form of recreation when compared with the other. This was kept up every school day for nearly two weeks, at the end of which time the class had not only become proficient in the shoveling and tempering of sand without thinking of it as drudgery, but was also thoroughly drilled in team work. Each student had had opportunity to act as gang foreman and had learned how to take orders from his fellows, and had also learned from the records of successive days that there was a "science" even in shoveling sand. These are items of much value in the handling of men and are requisites in the training of a successful foreman. Compare this with the same work as done by the average apprentice, and note the difference in spirit and in the mental effect upon the two sets of boys. In like manner, time and efficiency tests are made in molding standard patterns, and records are established which every member of the class strives to excel. These methods of stimulation are only employed for first arousing an interest in the work, after which a natural desire for knowledge is developed which is sufficient to maintain the necessary degree of enthusiasm without artificial means.

Another important point in the general scheme of instruction is to make the men feel that they are doing *real work* with tools and machines of latest design, and that all knowledge gained is of actual practical value. This is well illustrated in the machine department, where, as elsewhere, work

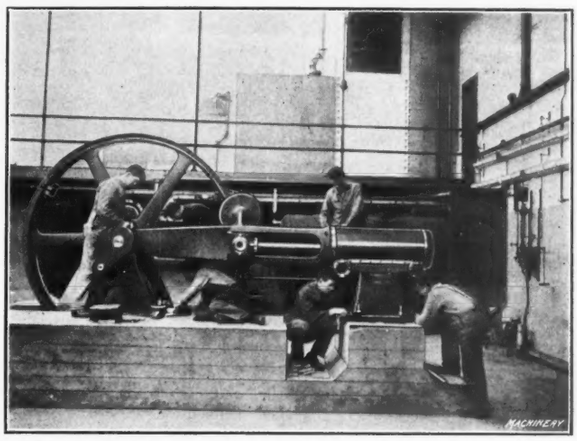

Fig. 10. Students assembling an Experimental Engine in the Steam Engine Laboratory. All Work of this Kind is done by the Students under the Direction of a Foreman

is carried through with the same order and system which would be employed in the most up-to-date shops. The article or machine to be built is first designed in the drafting-room, the patterns made in the pattern shop, and the castings in the foundry. The bench-work and machine-work are then given out to different men in the shop and the work is carried on to completion. In order to give a well balanced course, the men are shifted from machine to machine as fast as

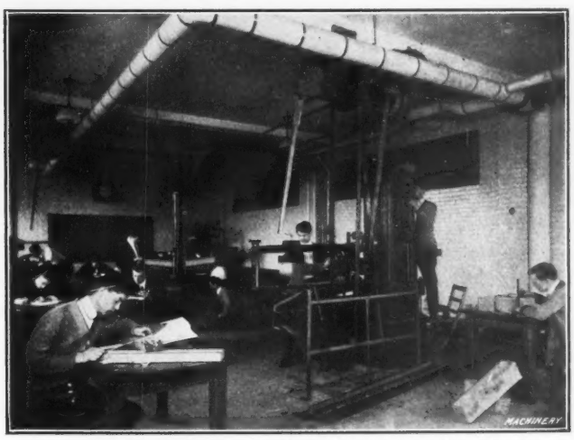

Fig. 11. The Testing Laboratory where Materials entering into the Construction of Buildings and Machinery are tested for Strength

they become proficient in their use, and in this way they have an opportunity to work upon the different parts of any article or machine which is being built in the shop.

No man is held back in his work by another, promotion being dependent upon individual proficiency in each case. Nor is a man kept from using a valuable machine for fear he will damage it, as is often the case with an apprentice in a shop. He is given instruction in the use of each ma-

chine with an opportunity to put it in practice. Until he become thoroughly familiar with it, his work is kept simple. In this way the risk of damage is small.

Another feature of interest is the testing of work after it is finished, to see how it may be improved in design. For example, one of the exercises consisted of the design and construction of an arbor press. After completion, one of these was taken to the testing laboratory and each part tested to the breaking point under the kind of stress to which it would be subjected in actual use. The main casting was broken and the weakest section ascertained; the teeth on the rack of the ram were tested and compared with the teeth on the pinion and the maximum strength of the handle was

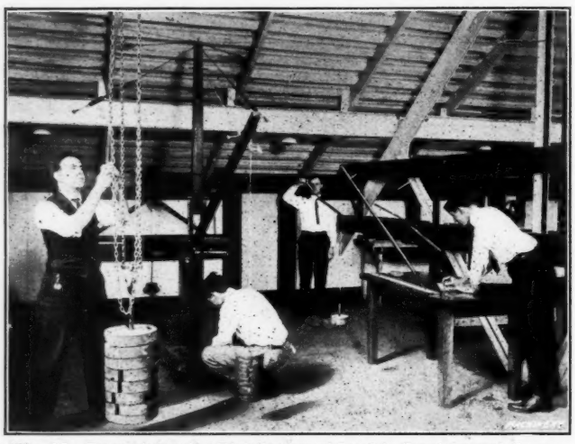

Fig. 12. Determining the Distribution of Load in Derricks and Cranes, using Specially Designed Apparatus

found. In this way the design of the machine may be revised, strengthening some parts and lightening others, to make the whole of uniform strength throughout. It is a noticeable fact that the men, as a rule, get a better grasp of theoretical problems of this kind when they can see their practical application to their particular line of work. The variety introduced into each day's work contributes greatly to its success. The school day is divided into four hours of drawing-room, class-room, laboratory or other theoretical work, and the same length of time is given to practical applications in shops or foundry.

In much that has been described there may appear to be a similarity with other trade schools, but the essential fact which seems to differentiate the Wentworth Institute from others with which the writer is familiar is the perfect blending of the spirit of investigation and open-mindedness of the best schools of science with the spirit of industry and production of the best commercial shops. In every course, theory and practice are carried on together in all the work, and theory is only taught so far as its practical application can be demonstrated.

The objection may be raised that this will have a narrowing effect upon the student, and that the instruction should be more general in its character. It must be remembered, however, that these young men are not university students to whom time and money are not of prime consideration, and who are simply laying a foundation for some special work later. The short length of the course is of the greatest importance to the type of men who enter the Wentworth Institute, and the sacrifice which they make for it is such that it must show practical results in higher wages as soon as it is finished. For these men, later success must come from practical experience obtained in passing upward through the different stages of their chosen trades, and not by passing over it, or dipping into it from the top, as a university student might do. The primary aim of the Wentworth Institute is to so equip its graduates, that with the later experience to be obtained in actual work, they may become superior workmen, foremen, and superintendents. The work done in the school is not intended to take the place of shop experience later on, but is expected to shorten this period at least one-third, and make advancement more rapid and more sure.

In addition to this, if a man develops superior ability as his work progresses, he can broaden his knowledge by further study to better advantage than at an earlier period. While a foundation, if sufficiently broad and deep, will support almost any structure, it is well in this short and busy life not to spend too large a share of it on the foundation alone, before finding out what it may be called upon to carry. The man who avails himself of the advantages of the Wentworth Institute, and subsequently works his way upward to better things, has constructed a foundation of sufficient depth to support almost anything he may wish to place upon it. If he desires to broaden this foundation, it is easily added to without tearing down that which he has already built. When a man has reached the point in his career above alluded to, he knows pretty accurately what his foundation is to support and can finish its construction without waste of time or material.

An advantage of the location of the school is its nearness to the manufacturing district of Roxbury, where various shops and factories are open to the students, thus permitting them to see in practical operation many of the machines and methods employed in the various courses of instruction at the school. A great number of courses are given, in order to meet the requirements of different classes of men. They are briefly outlined below. The one-year day courses include instruction in carpentry, electric wiring, plumbing, machine work, patternmaking, and foundry work. These one year courses are designed especially for apprentices, and aim to give a more thorough foundation than can be obtained in the commercial shop. It is not expected in this short time to turn out finished workmen, but to give the students a thorough understanding of the principles involved, together with sufficient manual skill, so as to enable them to gain a full mastery of their trade in a much shorter time than would otherwise be possible.

The two-year day courses have for their object the training of men to become superior workmen, foremen, and master mechanics. They include instruction in machine construction and tool design, and electrical construction and operation. The general methods of instruction are similar to those already outlined, except that the increased length of time makes it possible to teach the scientific principles in a more thorough manner. It also makes it possible for the student to obtain a greater degree of skill in the use of both hand and machine tools. Evening courses in seventeen practical

Fig. 13. Another View of the Mechanical Laboratory showing Students making Friction Tests on Pulleys and Gears

trades are offered to young men who are employed in mechanical trades or industries during the day.

The directors have also inaugurated part-time courses in addition to those noted above. These require the students to attend their classes at the institute every other week, but give them an opportunity to work at some regular employment during the alternate weeks.

* * *

The ribs of a gear should never be made flush with the rim or hub, but should come from ⅛ to ¼ inch below the rim or hub face; otherwise the rim and hub cannot be finished without making an unsightly appearance.

INDUSTRIAL ADMINISTRATION AND SCIENTIFIC MANAGEMENT*—1

WHAT CONSTITUTES SCIENTIFIC MANAGEMENT

By FORREST E. CARDULLO†

The work of the engineer may be divided into three great departments, since it has to do with the design of machinery, the methods of constructing and operating it, and the administration of the plants in which it is constructed and operated. The first two departments (namely the design of machinery, and its construction and operation) have received the careful attention of trained specialists for more than a century. Even at the beginning of the nineteenth century when engineers first began to apply the resources of modern science to their work, the arts of machine design and construction were in an advanced state, owing to the efforts of many generations of skilled mechanics. The third department of engineering work, however, has lagged far behind the other two, since comparatively little attention has been bestowed upon it. It is doubtful if any substantial advance in industrial administration was made in the thirty centuries preceding the year 1880, and even at the present time only a few men are devoting serious attention to the fundamental problems of management.

Importance of Industrial Administration

At the present time, industrial administration is the most important of the three departments of engineering work. It is not, of course, confined to purely engineering projects, but is an essential part of all commerce and manufacturing. Since the greater part of our working population is engaged in some kind of industrial work, the proper supervision of their efforts is a matter of prime importance to the well-being of the country. Most of the readers of MACHINERY are, or ought to be, interested in the proper administration of the mechanical industries. Hence, this series of articles will discuss more particularly the management of shops and factories engaged in the metal trades.

As has already been intimated, the art of industrial administration was stationary for a long period of time. In spite of tremendous changes in our social, economic and industrial systems, we have been content to adapt or modify methods which originated thousands of years ago. I may liken the system of administration which obtains in most industrial plants to one of those "old homesteads" which dot our New England landscape. They started as a log cabin, to which was successively added a lean-to, a barn, a shed, an ell, an upper story, and other "modern conveniences." As a result, they are roomy—and also inconvenient. The common system of industrial administration is constructed of the surviving remains of Greek slavery, Roman militarism, Saxon serfdom, the medieval guilds, and various other historical oddities, slightly altered to adapt them to the twentieth century conditions, and engrafted on one another in very much the same way as the additions to the old house. This system of management has been a growth in which each manager appropriated those developments of the past which appealed to him. Sometimes methods were adopted as a result of a carefully and properly conducted investigation, but nine times out of ten they were adopted because the manager "guessed" they were the best ones.

Conventional Management

We will designate the system of management described in the preceding paragraph as "conventional management."‡ It must not be inferred from the description the writer has given that conventional management is always and utterly objectionable. When the manager is a good guesser, he will usually choose good methods of work. If his lieutenants are able and energetic, these methods will be well carried out. Of course the system is not perfect, and in many cases it is not even satisfactory. Nevertheless conventional management can be made to work, and to work well, when it is in the hands of capable administrators. Different men will, of course, adopt different methods, and in different shops we will find that the work of administration is carried out in very different ways. In every case, however, the distinguishing feature of conventional management is the acceptance of something already in existence and the choosing, by guess, between methods which have been developed by someone else.

Systematic Management

Within the past thirty years, however, two other systems of management have arisen. One of these may be called "systematic management," while the other has been named by its originators, "scientific management." The systematic system of management is the development of the clerk and the bookkeeper. It aims at the keeping of careful records and the collecting and classification of information. It aims to proceed by continually bettering existing records. It aims to inform the management as to the preferable one of two alternative methods of work, each of which must be tried out in practice. Systematic management is, then, simply the keeping and comparison of records in order to determine the relative value of methods of work.

Scientific Management

Scientific management, on the other hand, has been developed by the engineer. Scientific management aims at the careful investigation of every problem of the industrial world in order to determine its best solution. It is not content to rely upon records, or upon the judgment of the most experienced workman. It brings to its aid all the resources of science. Every possible method of performing a piece of work is carefully analyzed and the best elements of all of the methods combined in order to form a new method. Having established the best methods of work, scientific management then instructs the workman how best to perform his task, and offers an incentive to do it in the prescribed manner. Scientific management is often called the "Taylor System" in honor of its foremost exponent.

Scientific management is not an invention but a discovery. It is the application of the scientific method of research to the problems of the industrial world. Insofar as it is concerned with the investigation of these problems, it is science and nothing else. Insofar as it is concerned with the proper application of the results of these investigations, it is management and nothing else. The combination is therefore correctly termed "scientific management."

Just as in the old days, certain types of machinery reached a very high state of development without the aid of the scientifically trained engineer, so in these days, the administration of certain of our industries has been very highly developed without the aid of scientific management. In some kinds of work, as for instance, watch making, the problems of administration are simple on account of the limited character of the product and the extensive use of automatic machinery. In industries of this class reasonable piece-rates have been established by a series of cuts and after prolonged labor troubles. Such industries have arrived at an efficient system of management by a very strenuous and unpleasant process, and the adoption of scientific management would not always bring notable advantages. On the other hand, most industries are not in this class. The character of the labor employed, the quantity and character of the output, the kind of machinery used, and the kind of material supplied, is continually changing. In the first class of industries a process of evolution extending over two or three generations has established the best methods of management. In the second class of industries the best methods are continually changing as conditions change.

In most industries, the introduction of scientific management promises to effect great gains, and to greatly increase the efficiency of our whole industrial system. Scientific management has been applied to many different kinds of work, and seems to be almost if not quite universal in its applica-

* For articles relating to scientific management previously published in MACHINERY, see "Scientific Management from a Social and Economic Standpoint," June, 1912; "Industrial Efficiency," May, 1912; "Helping a Man to find his Place," May, 1912; "The Efficiency Engineer," February, 1912; "Saving Time in Machine Work," February, 1912; "Scientific Management in the Seventies," January, 1912; "Scientific Management of Arsenals," December, 1911; "Task Work—The Basis of Proper Management," December, 1911; "Scientific Management of Railway Shops," September, 1911; "Scientific Management and Economic Problems," July, 1911; "The Art of Cutting Metals," August, 1907; "The Utilization of Labor," April, 1907; "One Thing at a Time," January, 1907, and the series, "On the Art of Cutting Metals," from January, 1907, to August, 1907.

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‡ Mr. Gilbreth has designated this form by the term "traditional".

tion. It has brought to light many problems in connection with industrial administration of whose very existence we were previously ignorant. Every time it is applied to a new set of conditions, even in the same industry, new problems are presented. If, in the near future, it is extensively applied to all industries or even to any one industry, it will give rise to very serious political, social and economic problems as well as intensify a great many of the problems that are now pressing for a solution. It will be seen, then, that the application of scientific management in industrial administration is not only important to the factory owner, the superintendent, and the workman, but to the law maker, the citizen and, in fact, to every man, woman and child in the country. The field of industrial administration is a very great one, but we cannot appreciate the importance of a right understanding of the problems which will be raised by the extensive introduction of scientific management until we realize how this field is interrelated with our entire political and social system.

An Example of Efficient Management

It is a fact which cannot be controverted, that very few shops in this country produce more than sixty per cent of the work which it would be possible for them to produce with the same wage roll and the same physical equipment. A few of the best managed shops produce probably eighty per cent of the work which it would be possible for them to produce, and occasionally departments in well managed shops reach an efficiency of over ninety-five per cent. On the other hand, there are numerous shops in this country which, without any considerable change in their equipment or increase in their wage roll, could produce from three to five times as much work as they put out at present. This statement, extraordinary as it may seem, is not the result of a wild guess, but may easily be verified by any one who will make a study of conditions in these shops. Some two years ago, the writer made a trip through southern New England inspecting some of the representative industries. The most efficient department that I ever saw was the grinding department of the Norton Grinding Co., Worcester, Mass. I do not know that the engineer, Mr. Norton, made a conscious attempt to install the system developed by Mr. Taylor, but I do know that by a careful study of the work of this department he has raised the standard of efficiency so that every man that I saw was employed continuously in producing a very high class of work with a rapidity that was astonishing, and by methods which the average shop foreman would say were impossible. In conversation, Mr. Norton emphasized the necessity of a careful study of shop problems and stated that such problems were worthy of attention from the most highly trained engineers. Although he never once used the term "scientific," it was quite evident that his study was scientific in the best sense of that term, and that no single problem which had presented itself in his grinding department ever escaped a most thorough and searching investigation. I shall always remember this department of Mr. Norton's works as one of the finest examples I have ever seen of excellent management, and also I shall always remember the type of employe which I saw in that department as a representative of the very finest type of the American mechanic. Every man seemed to be a man of unusual intelligence and skill and seemed to be putting into his work that indefinable something, which for lack of a better term we designate as "brains."

A third matter which attracted my attention was the fact that Mr. Norton seemed to be personally acquainted with every man working in that department; seemed to know their especial abilities and the work for which they were best fitted, and seemed to take great interest in seeing that each man was doing the kind of work for which he could realize the highest pay. So far from adopting the attitude of the average employer, who is inclined to think it a matter of good business policy if he can drive a sharp bargain with his men, and obtain a day's work for a minimum wage, Mr. Norton spoke with pride of the unusual earnings of several of his men who were working under a premium system.

An Example of Inefficient Management

At another time I visited a concern in which it seemed to me that the majority of the men were doing absolutely nothing that was useful. This concern was one of the largest ship building yards of the Atlantic coast. I had no opportunity to talk with any of those responsible for its management and therefore cannot say what attitude they adopted toward various questions of administration. There did, however, seem to be a dearth of foremen, and as in the time of the Judges in Israel, "every man did that which was right in the sight of his own eyes." I remember seeing one man who was engaged in chipping a plate with a pneumatic hammer, and he had two assistants whose duty seemed to be to drag the air hose after them and carry his hammer as he went from place to place. At another place I saw a man measuring a plate and marking upon it an opening which was to be made in a bulkhead, with five or six workmen lounging around him doing nothing. Most of the work of the establishment seemed to be conducted in that manner, and altogether, it was the most disgusting exhibition of shiftless management that I have ever seen in my life. The matter was so apparent that several students who were with me at the time called my attention to it, although they were men unaccustomed to shop administration and most of them were men totally unfamiliar with methods of shop work.

Administration of Average American Shop

The administration of the average American shop is a mean between the slipshod methods of the shipyard and the careful and efficient methods of the Norton Grinding Co. In such a shop, such obvious inefficiency as I have described in the case of the shipyard, would be promptly squelched. On the other hand, in such a shop, careful investigation will usually show very great inefficiency in many departments although such inefficiency is not at first obvious. This inefficiency is due to a variety of causes. It may be that work is slack and the workmen are "nursing their jobs" in order to avoid discharge. It may be that they are prolonging an easy and agreeable task in order to avoid being assigned to a more difficult and disagreeable one. It may be that illness or unsanitary shop conditions have deprived the workman of a measure of his usual energy and ability. In many shops, inefficiency has nothing to do with the workmen, but is entirely chargeable to the management. All of the men appear to be busily employed and the work to be carefully conducted, but at the same time, the type of machines used, the sequence of operations employed, the conduct of the toolroom, or any one of a dozen different things for which the management is or should be directly responsible, greatly reduces the efficiency of the shop.

The writer was once employed by a firm that manufactured small steam engines for the oil trade. Each of these engines was equipped with two flywheels weighing about 600 pounds apiece and the only machine work done upon the wheels consisted in boring the hub, reaming it, and cutting the keyway. I was employed to bore the hubs, which was done upon a homemade machine having a stationary spindle and a revolving table. There was a crane which was used to place the wheels upon the table, but before the wheels could be lifted by the crane, they had to be brought about 500 feet from that part of the yard in which they were stored after being cast. I was instructed to get another apprentice who was named Gus, to help me roll them from the storage yard to a point under the crane. During this time, both my machine and Gus's machine were idle, since they were of a character which required constant attention. This job had to be done several times a day, and I doubt if those two machines were running more than half the time.

As I remember conditions in that shop, I can see that there were endless possibilities of increasing the output by improving the methods of management. Nevertheless, to one who is not in the habit of thinking about the possibilities in this line, the shop appeared to be busy and well managed. It was conducted by a foreman who had an excellent reputation and who was supposed to know "how to get out the work." He was a man of considerable experience and knew about how much time certain work would take when done by the average

machinist in the average way. Most shops would have considered him a valuable acquisition, and in a great many shops he would have introduced notable improvements. The ship building company I have already described would have been fortunate had he taken their affairs in hand, but any department managed by him would have made a sorry showing alongside of the grinding department of the Norton Grinding Co. He employed the usual methods of conventional management, that is, he allowed his men to choose their own methods of doing work, and then eliminated those men or those methods which were obviously incompetent or inefficient. He was not at all versed in the scientific plan of finding the methods of greatest efficiency, and of applying them in the administration of his department.

Misapprehension of Principles of Scientific Management

I have heard a good many men say, in regard to scientific management, that they have managed their affairs scientifically without knowing that they were scientific. However, when I have come to talk over the matter at length with them, I find that what they mean is that some of the inefficiencies not usually obvious had become apparent to them, and that they had adopted some of the methods of scientific management in attempting to eliminate the inefficiences which had come to their attention. This is a very different matter from installing a system of scientific management, although the efficiency of a good many plants has been greatly increased in this manner. However, the men of whom I speak do not understand what scientific management is. They think that scientific management is a collection of best methods, that it necessarily involves the use of certain kinds of blanks and records, or that it is a form of organization, a method of wage payment, or something of that kind. Of course such things are employed in scientific management, but they are only the tools which it uses, and just as a carpenter will change his tools for different kinds of work, so scientific management will adopt different methods, different forms, or different plans of organization, as conditions change.

A great deal of harm is likely to come from the unintelligent employment of some of the methods of scientific management by such men, even when they are acting in the best of faith. The introduction of some of the methods will often cause antagonism among workmen, and they will sometimes prove inefficient under new conditions. In either case scientific management is blamed for the failure, when, as a matter of fact, scientific management would probably have employed other methods under the given conditions. *Scientific management must not be confounded with its forms or its methods*, just as a man must not be confounded with his clothes, or a religious creed with its form of church organization.

Methods under Different Types of Management

It will help us in our consideration of different types of management, if we take a concrete example and note the differences of the several types, as they appear in the example. Let us suppose that a piece of lathe work is to be done, such, for instance, as the turning of a crankshaft. In the conventional type of management the foreman will assign such a job as this to the first man having a vacant machine in which it can be conveniently performed. Systematic management will usually do the same thing. Scientific management, on the other hand, will assign the piece of work to that machine in which it can best be performed.

Having received the work, under conventional management, the workman will determine the plan of procedure, will choose and grind his own tools, and will proceed to work, using those feeds, cuts, and speeds which he thinks will be the most satisfactory. In case the workman is receiving day wages, the pace of the work will depend upon the foreman. As the foreman goes about the shop, he will occasionally take notice of the condition of the work and the way in which it is being performed. If the workman is obviously incompetent or inefficient, the foreman will instruct, reprimand, or discharge him, as his judgment will warrant. On the other hand, if the work appears to the foreman to be going forward at a reasonable pace, nothing will be done.

In case the workman is being paid by some piece-work or premium plan, he will be anxious to earn as large a wage as possible and therefore will attempt to determine the best cuts, feeds, and speeds for the work in hand. There are two methods open to him for doing this. One is to guess at the best conditions and the other is to experiment until he has determined them. The first method, of course, leaves much to be desired. The second method is open to the objection that it takes a considerable number of experiments to determine the best conditions of work, even when the experiments are confined to the performance of a certain job on a certain machine. The workman is rarely, if ever, able to devote the necessary time to such experiments, and he has not the training which would enable him to properly perform and record them. With the facilities which he usually has at hand, it is impossible for the average workman to do any more than gradually improve his performance by careful attention to his methods of work.

Conventional management determines the time required to do a piece of work, or the piece-rate to be paid for it by one of two methods. The first method is for the foreman or some other experienced person to guess at the time required to do the work. The other is to put a capable and conscientious workman at the work and see how long it will take him to do it. Of course the guess of the foreman is about as good as the guess of the average drummer would be if he tried to estimate the population of a village while he was riding through it on a train. The other method of allowing a pace maker to determine the piece-rate is a better one. Since, however, the pace maker usually does not have the opportunity of making a careful study of the best methods of performing the work, his time allowance will usually be too large.

Systematic management, like conventional management, leaves the method of performing the work entirely to the workmen. It does not, however, leave the question of the proper pace to the foreman. The records of previous performances have established a pace and the management can readily determine whether or not the work is being conducted at the best pace of which there is previous record. If it is not, the foreman is notified and the workman is obliged to increase his pace. He may do this in one of two ways. He may experiment in order to determine the possibilities of the work, or he may go to someone who knows more about it than he does for assistance and instructions in regard to feed, cuts, speeds, and methods. In either case he is nagged into bringing up his pace to that of the previous man, and in this way the production is kept up to the best previous record.

Under scientific management, the sequence of operations, the cuts, feeds, and speeds, the tools and appliances, and the methods of work are determined by the management and not by the workman. Before the work is commenced, a specialist considers all the possible methods of doing the work and after carefully analyzing them determines which of these methods are the best. Having fixed upon the methods of work, a time allowance is then established for each operation. A typewritten or blueprinted instruction sheet is then prepared which informs the workman exactly what he must do, and how long it should take him to do it. Instead of grinding his own tools, he receives a supply of properly formed and ground tools. Instead of depending upon the foreman or upon previous records for establishing the pace of work, the time required to perform each of the several operations is exactly known. The whole series of operations has been subjected to a careful analysis, every possible variation has been considered, and the methods developed are not only good ones, but are the best possible ones, considering the limitations of that particular shop.

In order to accomplish the best results, not only must the workman receive an instruction sheet, but he must be shown how to perform many operations. One of the officers of administration is, therefore, the teaching foreman, who makes it his business to instruct the men in the proper ways of doing work and who is always ready to come to the aid of those men who are unable to perform their tasks in the allotted time.

In order to encourage the workman to follow the proper methods of work and to perform his task in the allotted time,

a piece-work, premium, or bonus plan is adopted for the payment of wages. The plan which seems to give the most satisfaction is known as the Gantt bonus plan. This consists in paying the man a certain definite percentage of his daily wages as a premium whenever he performs his task within the allotted time. If his task, for instance, consists of ten pieces a day, and he succeeds in making ten or more pieces, he will receive from twenty to sixty per cent additional wages as a premium. In case he produces less than ten pieces, he receives the regular day wages, but no premium. A man's earnings are computed each day and he knows on the morning of the following day whether or not he has earned the premium. If he has not, it is the duty of the teaching foreman to go over his work with him and instruct him in those points in which he may be deficient. In order to make sure that this teaching is thorough and effective the teacher receives as a bonus a fraction of the bonus earned by his workmen and in case all of his workmen earn bonuses, the teacher receives an extra bonus. It will readily be seen that with such a system of wage payment, thorough instruction and cooperation are the invariable order of the day, and that the foreman as well as the workmen are always on the lookout to see that the tools, machines and stock, are all in perfect condition.

Not only does the man receive adequate instructions, and a reward for obeying these instructions, but he is offered every reasonable facility for doing his work quickly and well. He does not have to spend his time hanging around the smithy or the toolroom getting the things that may be needed for his work. He spends no time repairing his machine, taking up the belts, or fixing the tools supplied to him. The management makes it its duty to see that nothing hinders him in his work so that his entire time and attention may be devoted to the performance of, and not to the preparation for, that work. This requires that certain assistants shall perform tasks which conventional management usually delegates to the workman himself.

Collecting Data Necessary for Scientific Management

It will be apparent from the foregoing, that instead of depending upon judgment, scientific management depends upon knowledge, in its task of administration. Judgment is the instinctive and subconscious association of impressions derived from previous experience. When a man's experiences are wide, his impressions of them are correct, and his memory is good, his judgment will be good. But even the best judgment falls far short of knowledge, and any system of administration based on judgment alone must fall short of scientific management. Judgment will always have its place in any system of administration for two reasons, firstly because knowledge cannot always be obtained, and secondly because it may sometimes cost more to obtain it than the knowledge is worth. In either case judgment is valuable, if not absolutely necessary. But at the best, judgment is only a guess and not to be relied upon if accurate information is available. Not only does scientific management depend upon knowledge, but this knowledge is carefully and systematically collected and the data so obtained are classified and digested until the knowledge is instantly available whenever a problem is presented to the management. Back of the form of organization is a knowledge of the needs and the work of the plant. Back of the plan of wage payment is a knowledge of psychology and sociology. Back of the instruction sheet is a knowledge of the sciences of cutting metals and of handling work. As examples of the way in which such knowledge is obtained, let us take the two subjects last mentioned, and see what scientific management has done to develop the sciences of cutting metals and of handling work.

Most readers of these articles are doubtless familiar with the paper of Mr. F. W. Taylor on the art of cutting metals, which was published in abstract in many of the technical magazines shortly after it was delivered, in 1906. The work described in this paper is probably the best example of the scientific study of methods of manufacture which has ever been made. Mr. Taylor and his associates at the Midvale and Bethlehem steel companies were engaged in the work for nearly twenty-six years, and during that time made many notable discoveries in the line of their work. One of the most important of these was the discovery of high-speed steel; which is, at a very conservative estimate, worth fifty million dollars per year to the machine industry of this country. Other no less important but less spectacular results were the discovery of the best forms for cutting tools, the invention of a slide-rule for the determination of proper cutting speeds, and the resulting developments in the form, rigidity, and power of machine tools.

In making this investigation suitable machines were prepared and after establishing certain standards in regard to the kind of material to be cut, the form and chemical composition of the cutting tools, and the length of time which the tools must run without regrinding, a very elaborate series of tests was made. The object of these tests was to determine the maximum permissible speed of cutting with different feeds, depths of cut, kinds of tool steel, forms of tools, classes of material, and conditions of work. There were in all twelve conditions affecting the cutting speed, each of which could be varied. Some of these could be varied over a very wide range, and every time one of the conditions was altered a large number of experiments was necessary in order to determine the permissible cutting speed. It is obvious that in such a complicated problem as this, thousands of experiments were necessary before it could be solved. As fast as experimental data were collected, the results were worked up in order to determine the mathematical laws governing the cutting of metals. Since these laws were found to be extremely complicated, and since, if the work was to be practical, quick and simple methods of solution had to be devised, a great deal of time and effort was spent in devising methods for determining the proper cutting speeds for any given conditions. Finally after many years of work, a slide-rule was invented which gave a quick and accurate solution of the problem.

This investigation was probably the most important investigation of the kind ever attempted. It was very thorough, requiring a period of twenty-six years for its completion. The total cost is stated to have been $800,000. The results, in which every metal working shop in the country has shared, are unquestionably worth one hundred million dollars a year. Hardly one manager out of one hundred, probably not one mechanic out of a thousand, realizes the immense value and scope of the improvements resulting from this investigation. They rank in importance with the development of the steam engine, the railroad and the printing press. There are equally great opportunities for a dozen, possible one hundred investigations of like character in other industries. It is to be hoped that they will be soon commenced and that they will be prosecuted with the same energy, tenacity and intelligence with which this investigation was so greatly marked.

Motion Study and Analysis

The method employed in determining the best way to handle work is known as "motion study." Motion study is almost a science in itself, and is really a branch of applied psychology. Motion study is not peculiar to scientific management, but has long been utilized by athletes in their endeavor to improve athletic records. A high jumper, for instance, will carefully train himself to do his work in a certain way, taking a certain number of steps in running up to the bar, throwing his limbs and body in a certain position as he jumps over the bar, and endeavoring in every way to develop that smoothness and machine-like precision of action which characterizes what he terms "form." The hurdler does the same thing, day after day making trial of different methods of running and jumping, timing himself by the stop watch, in order to achieve the most perfect form.

The same sort of study can be employed to advantage in training workmen to perform their tasks, when the tasks are repetitive in character. There is, however, one very great difference between motion study for the athlete and for the workman. Whereas the athlete strives to perform a task which taxes his strength and endurance to the limit, the workman strives to develop that form which will enable him to perform his task quickly and with a minimum of fatigue. In the case of the athlete, he is striving to excel for one supreme moment. The workman, on the other hand, must be

trained to repeat his task, day after day, month after month, year after year, without injury to his strength or his health, because only in that manner can the industry in which he is engaged reach its maximum prosperity. It takes a more carefully trained observer and a far better understanding of men and their physical capabilities to train a workman to do a task quickly and well without over-exertion, than it does to train an athlete to perform his task quickly and well, where the question of over-exertion does not come in.

Any one who has ever had anything to do with athletics understands how impossible it is for a man without training to compete with the trained athlete. Just as it would be impossible for the average healthy and vigorous man to enter an athletic contest and do creditable work in competition with trained athletes, so it is impossible for the average workman to go into a shop and accomplish a creditable amount of work, in competition with a workman who has been properly trained after a motion study has been made of his task. In the same way, just as it is impossible for the average man who likes to look at the stars, to predict the time of an eclipse or the future configuration of the heavens, so it is impossible for the average machinist to compete with the trained engineer who has at hand a slide-rule which will tell him exactly the cuts, feeds and speeds, which it is possible to employ with a given class of material and a given machine. We find it advisable to employ designing engineers who have spent years in studying the strength of materials and the sciences upon which engineering depends. It is equally advisable to employ another class of engineers who will study the principles of management, and methods of doing work.

So far we have only touched on two points in regard to the turning of our crankshaft, namely motion study and the science of cutting metals. There are a dozen other branches of science involved in the direction of the shop, all of which are used by scientific management in furthering administration. When we consider these things, it becomes apparent that in many industries the introduction of scientific management will completely revolutionize methods of work, methods of administration, and even methods of selling the product and of financing the industry.

It will be seen from what has just been said that scientific management is by no means a simple matter, that it requires forethought and care in its application, and that, above all things, it requires the scientific spirit in order to make it successful. It will also be apparent to every one, that while scientific management will very probably greatly increase the output per man or per machine, the staff which it requires for the planning of the work, for the conducting of experiments, and for keeping workmen supplied with material and tools, will be quite an expensive one. The question of whether or not scientific management is profitable, and therefore practicable, will hinge upon the question of whether the savings which scientific management will effect, will pay for the staff which it is necessary to maintain. In my opinion, the savings will usually be more than sufficient to pay for the extra cost of scientific management, although sometimes they will not. The application of all of the methods and machinery of scientific management to the pattern-shop, where every job is different and where the principal part of the work consists in planning rather than in executing, will not usually be a success. On the other hand, where scientific management is applied to repetitive work, there is no question but what the cost of maintaining the staff will be but a very small fraction of the savings which will result.

* * *

During the past year 29,353 applications for patents were filed in Great Britain. Of the foreign applications those from Germany and the United States were most numerous; 3304 applications were of German origin, while 2670 were received from residents of the United States. The United Kingdom, of course, contributed the largest number, or 19,579 applications. During the year, five applications were filed for the revocation of patents not worked to an adequate extent in the United Kingdom. Two of these applications were granted; in one case the application was dismissed; in one the patent expired during the proceedings; and the fifth case is pending.

A BALL RACE GAGE

The accompanying illustrations (Figs. 1 and 2) show a ball race gage, which is used in the works of the Cadillac Motor Car Co., Detroit, Mich., for gaging the diameter of the ball race in a ball retaining ring. Two of these rings form a thrust bearing to reduce the thrust on the main drive shaft of an automobile. As shown in Fig. 2, this gage consists of a cast-iron stand *A* in which a hardened and ground steel ring *B* is retained. The top portion of this ring is made a good fit for the inside diameter of the ball-retaining ring *C*, which when being gaged is simply slipped over the top portion of ring *B*. A stud *D* held to the base by a nut, as shown, is slotted to receive the gage frame *E*. Stud *D* is hardened and ground, and the plate *E* has a reinforced piece *F* held to it by rivets, the latter being hardened and ground and made a good fit in the slot in the stud. The fulcrum of the pointer or needle *G* is so disposed that any variation in the work is magnified twenty-five times at the point where the reading is taken. A knurled handle *H* is fastened to the gage for convenience in holding it.

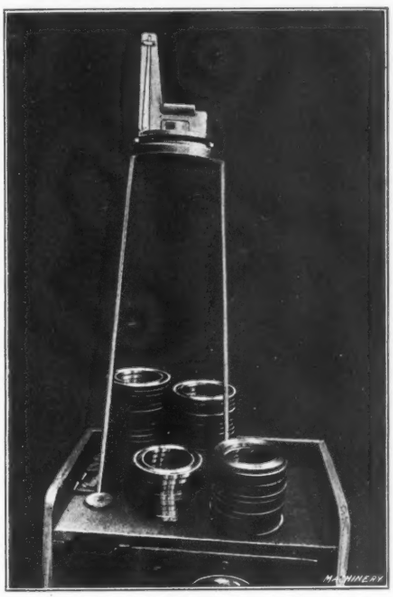


Fig. 1. Ball Race Gage in Use

In operation, the work is slipped over the ring *B* of the gage as shown in Fig. 2; then the gage frame *E* is placed in the slot in stud *D* and the gaging knife-edge rollers *I*, which in this case do not rotate but are held rigidly to the frame, are placed in the ball race. The position of the measuring point

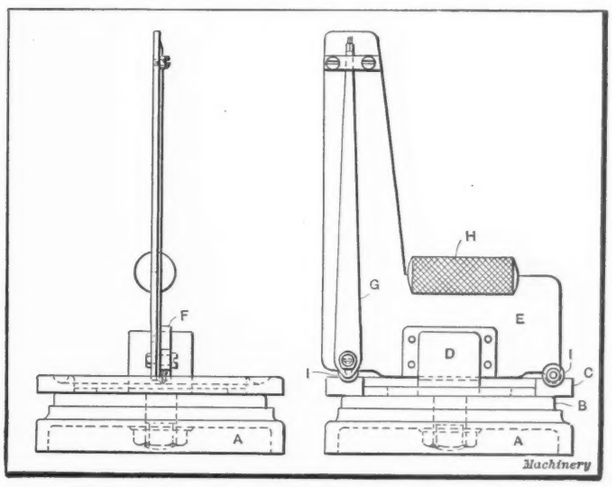


Fig. 2. Construction of the Ball Race Gage shown in Fig. 1

of the needle is then noted to see if the race is of the required diameter. A limit of 0.001 inch is allowed on the diameter of the ball race, the latter being 4.125 inches in diameter. The race is ground on a Brown & Sharpe generating grinder. As shown in Fig. 1, the base of the gage is fastened to a frame which is of sufficient height to bring the ring to be gaged in line with the operator's vision.

* * *

Bolts, cap-screws, or nuts, when used in connection with cored holes, should be supplied with washers for providing sufficient bearing surface for the nut or head.

THE EXTRUSION OF PLASTIC METALS*†

Although it had been found possible as early as 1850 to extrude such metals as lead and tin and thus form pipes and bars, the extrusion process had not, at that time, been successfully applied to the shaping, by means of extrusion, of such metals as copper, delta-metal, etc. It was when Alexander Dick, the inventor of the delta-metal, made some experiments with this material under high pressure and at high temperature, during the latter part of the eighties, that it was first shown that this material could be extruded in a heated state. There were, however, several difficulties to overcome. The extrusion process, as is well known, consists of hot plastic metal being pressed through a form or die at high pressure, so that a continuous bar or pipe of the cross-section of the die or form is produced. Lead and tin can be extruded at comparatively low temperatures (250 degrees F.), but copper and similar metals require temperatures all the way up to 1750 or 1800 degrees F.

The main difficulties to be overcome are to maintain the high temperature and plasticity of the metals during the extrusion, and to make press cylinders and dies which will be able to withstand the effect of the high temperatures and pressures. The first condition was met by Dick by filling

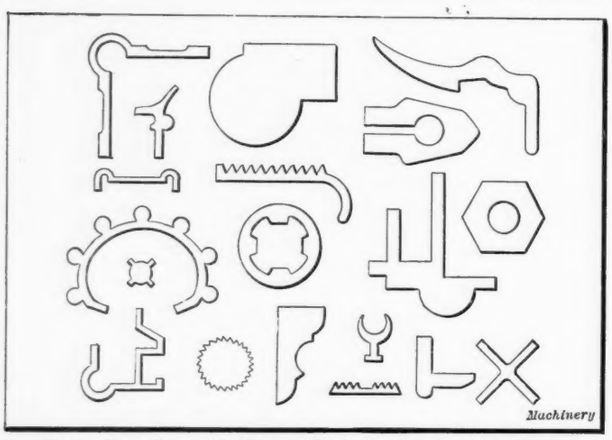


Fig. 1. Some Interesting German Products of the Extrusion Press

the press cylinder with molten metal and by surrounding it with heat insulating material, such as ground granite. In order to prevent the heated metal from forcing itself between the plunger and the cylinder, when the pressure was applied, a spherical steel piston was employed which spread when the pressure was applied, and in this way effectively closed the cylinder behind the metal.

The advantages of the extrusion process, as compared with the ordinary rolling and drawing process, soon became apparent. The extrusion process permitted parts of unusual cross-section to be produced in great quantities. In fact, sections could be extruded which could not be rolled under any circumstances. In Fig. 1 is shown a number of special sections which have been produced by extrusion. On account of the high pressure under which the metal is extruded it becomes more compact and its strength is increased. The extruded shapes, therefore, possess those qualities which make them especially useful in machine design. The surfaces are smooth, and free from flaws and other defects. The dimensions of the extruded shapes can be gaged with great accuracy, so that they may be used either directly or with very little additional finishing. After the advantages of the new method had become known, it was soon adopted and further developed by many different individuals and concerns.

Instead of pouring the molten metal into the press cylinder, it was found to be better to have it cast into blocks which were heated to a white heat and inserted in the press. In this way the time required for the setting of the metal in the press cylinder was saved, and the efficiency of the machine considerably increased. Further developments resulted in the perfecting of the press, and the metals used for the cylinders

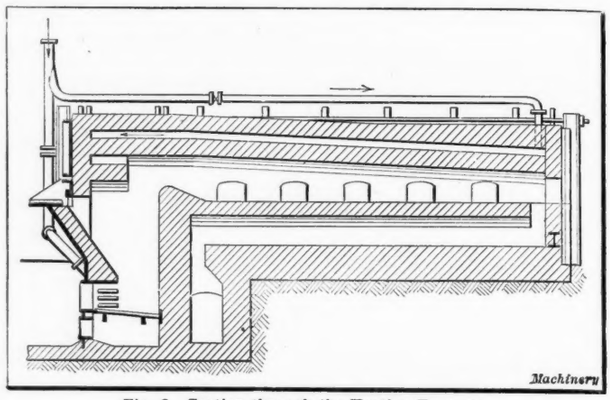


Fig. 2. Section through the Heating Furnace

and the dies. In order to retain the heat within the cylinder it was surrounded by a jacket and heated by special means. Several new presses were brought out, and besides the Dick press, those best known in Germany were built by the firm of Friedr. Krupp A.G., Grusonwerk in Magdeburg-Buckau. The object of this article is to describe the methods and processes used in connection with the machine. The complete installation consists of a foundry for producing the metal blocks, a heating furnace, and a hydraulic press and pumping arrangement.

The Casting of the Metal Blocks

The metal blocks are cast in long sections and are afterwards cut up into pieces of suitable size for the presses. The blocks are cast in permanent molds, and in order that as smooth a surface as possible may be obtained, it is necessary that the inside of the mold be of a close-grained metal, free from flaws. In order to still further insure against blow-holes or porous parts in the cast blocks, the molds are covered on the inside with a preparation, the same as is done in the casting of copper and brass in general.

After the blocks are cast and cut into parts, they are inspected for defects, and any burrs or fins that may be present are removed by chisels or scraping. Special care must be used

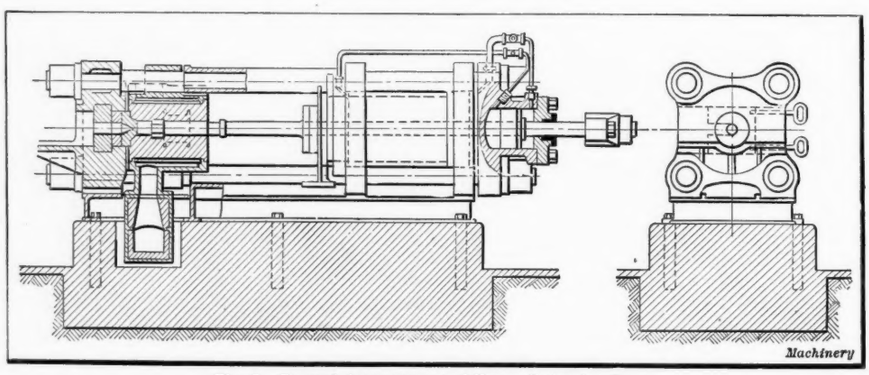


Fig. 3. General Arrangement of Krupp Extrusion Press

in producing hollow parts for pipe. In this case, it is especially important that the core be central with the outside, in order that homogeneous walls of uniform thickness may be obtained in the extruded pipe.

Heating the Metal Blocks

The metal blocks are heated in a special furnace which should be placed close to the extrusion press. The important feature about the heating is that the block must be heated clear through to the center, and not be brought to the press when merely the surface has been brought to the required temperature. A furnace used for heating the blocks is illustrated in Fig. 2. The blocks are inserted at the end opposite

* Abstract from an article by Friedr. W. Siepke, of Magdeburg, Germany, in *Werkstattstechnik*, April 15, 1912.

† See also "An Experiment in Extrusion," MACHINERY, June, 1912, engineering edition, and other articles there referred to.

the grate, and roll by gravity down the somewhat inclined surface toward the fire-box. When the required temperature is obtained, they are pulled out through an opening at the side. In order that good results may be obtained in the extrusion process, it is important that the blocks do not come in contact with the brickwork of the furnace. The surface on which the blocks rest is, therefore, covered with a cast-iron plate. The length of the furnace is made to suit the capacity and speed of the action of the press. The width is usually made about three feet. The heated blocks are most conveniently transferred from the furnace to the press by means of an overhead trolley.

The Hydraulic Extrusion Press

The hydraulic extrusion press shown in Fig. 3 is of the horizontal type. The press consists mainly of the hydraulic cylinder, the dies, the pressure chamber or extrusion cylinder, and a head which holds the dies. Four heavy connecting bars tie this head to the hydraulic cylinder. The pressure chamber is located between the head and the hydraulic cylinder and moves on four guide bars.

These presses are built in two sizes, the main dimensions of which are given in Table I. The output of the presses varies according to the size and form of the cross-section of the different extruded shapes. With trained operators and simple cross-sectional shapes, it is possible to extrude about 20,000 pounds of metal in ten hours in the small-size press and 35,000 pounds in the larger press. This output cannot be obtained, however, when tubing of difficult sections is being extruded. The figures given above correspond to two hundred press operations in ten hours. In order to be able to maintain this efficiency the press chamber must be sufficiently heated at the beginning of the work and there must be no interruption in the operation. For the complete installation required for one press, four men are necessary, one of whom works at the furnace.

Details of the Hydraulic Press

The hydraulic cylinder is made of steel casting and lined on the inside with a copper bushing. The pressure chamber is made of so-called "Krupp special" steel which even when heated has a high tensional strength. This chamber or cylinder is forged and is provided with a jacket of steel casting. Between the pressure chamber and jacket an open space is provided through which the heated gases from the fire-place arranged beneath the pressure chamber can pass. By this means the chamber is heated to the required temperature, the gases from the combustion escaping through a pipe

TABLE I. GENERAL DIMENSIONS OF EXTRUSION PRESSES

Dimensions	Smaller Size	Larger Size
Total pressure, pounds	1,430,000	2,200,000
Maximum pressure, pounds per sq. in	3770	4125
Diam. of hydraulic cyl., inches	22	26
Stroke, inches	27½	31½
Diam. of extrusion cyl., inches	4⅜	5½
Max. diam. of extruded bars, inches	2	2¾
Required horsepower	100-150	175-225

above the pressure chamber into the chimney. The required temperature to which the pressure chamber should be heated by external means is about 600 degrees F. This heat is required so that the metal blocks which are heated to some 1650 or 1800 degrees F. may not be suddenly cooled. Should sudden cooling take place, the surface of the metal block may lose its plasticity and the extrusion may either be unduly delayed or be made entirely impossible. The high temperature of the walls of the pressure chamber, while the extrusion takes place, requires an especially high quality of metal, and it has been proved in a number of instances that forged Krupp special steel answers the requirements better than any other known material.

In order to prevent too high a pressure in the hydraulic cylinder, a safety valve is provided on the pump which opens at a pressure of about 4500 pounds per square inch. In order to instantly relieve the pressure in the hydraulic cylinder, a releasing valve is inserted between the pump and the controlling valve on the machine.

The dies containing the shape for the extruded form are held in the head. This latter takes the pressure during the extrusion process. One of the greatest difficulties in the past with machines of this type has been to remove the remainder of the metal block in the pressure chamber when operations are suspended or when practically all the metal has been extruded. Part of the metal would usually be pressed in between the joints, solidify and make the removal of the various parts difficult. In the Krupp press this difficulty is taken care of as follows: As already mentioned the pressure chamber is placed between the head and the hydraulic cylinder, but is movable on four guide rods. A tapered hole is provided in the pressure chamber in the end towards the head, and the dies are formed with a corresponding taper. An auxiliary hydraulic cylinder is provided at the right-hand end of the press in Fig. 3, and the pressure chamber is connected with

TABLE II. INFLUENCE OF THE EXTRUSION PROCESS ON THE PROPERTIES OF METALS

Metal	Cast		Extruded	
	Tensile Strength, Pounds per Square Inch	Elongation, Per Cent	Tensile Strength, Pounds per Square Inch	Elongation, Per Cent
Copper	28,500	35	34,000	38–40
Zinc	27,000*	12	35,000	38
Magnalium	43,000–64,000	5	53,000–71,000	10
Aluminum	14,000–17,000	3	33,000–38,000	4.3
Delta-metal	83,000	11	98,000	21.8
Durana-metal	58,000–74,000	35	60,000–81,000	38

[* The tensile strength of cast zinc is given by several authorities at about 3500 pounds per square inch, and that of rolled zinc at about 16,000 pounds. The strength of cast zinc given in the table is 70 per cent greater than for rolled zinc, which seems to be a very high and doubtful value.—EDITOR.]

the piston of the auxiliary cylinder by means of a cross-head and two connecting-rods. By this means the pressure chamber can be operated. Before the beginning of the extrusion, the pressure chamber is forced against the die by means of this auxiliary cylinder, and due to the tapered hole and the tapered end of the die a very close-fitting joint is provided, so that the metal, during the extrusion process, cannot enter between the two surfaces. At the end of the extrusion, the auxiliary cylinder operates the pressure chamber in the opposite direction, thus opening up a space between the die and the pressure chamber and making it possible to easily remove the remaining metal from the top of the die.

The press can be operated with considerable rapidity. For simple shapes, it is possible to go through the complete cycle of operations for one metal block in three minutes, this time being divided as follows: Putting the metal block into the pressure chamber, 1 minute 25 seconds; extrusion, 50 seconds; opening up the space between the pressure chamber and die, 10 seconds; removing the remaining metal, 15 seconds; and returning to the original position, 20 seconds. The effect of the extrusion process on the tensile strength of various metals is indicated by Table II.

* * *

Franklin H. Wentworth, secretary of the National Fire Protection Association, stated at the meeting of the New England Foundrymen's Association, April 10, that out of more than 11,000 fires under automatic sprinklers, of which the association had records during the past fifteen years, there was not a single instance where the automatic sprinkler, when of standard approved make and installation, had failed to put out or hold in check a fire under it, except in cases where the system had been tampered with, or crippled by an explosion.

* * *

Undoubtedly many (accident) prevention appliances in use in Germany might well be adopted here, but the real and important difference is not in the prevention apparatus—it is in the prevention spirit. In Europe, and especially in Germany, accident prevention is kept constantly before the public, before the legislatures, before the employers, and before the workers.—*F. C. Schwedtman in "Accident Prevention and Relief."*

DETAILING CRANE GIRDERS WITH CURVED LOWER CHORDS*†

By CHARLES B. GILBERT‡

The detailing of crane girders with curved lower chords—that is, of the fish-belly type—sometimes involves considerable labor. The tables given in the accompanying Data Sheet Supplement were, therefore, compiled by the writer about three years ago, and have been used by the structural detailers of the Niles Crane Works, of Philadelphia, Pa. The tables have been carefully checked and have been in use so long that it is assumed that all errors have been eliminated. The tables have proved of great value as time savers when figuring the depth of curved girders, half the span being divided, for convenience, into five or ten equal spaces for spans of different lengths. A glance at the accompanying engraving Fig. 1, will explain the use of the tables, a crane girder having a span of 61 feet 3 inches having been assumed as an example. The curved part has a span of 60 feet; one-half of this distance, or 30 feet, is divided for the convenience of the templet makers into ten spaces of 3 feet each. The end ordinate, assumed here to be 1 foot, will be found at the extreme left of the tables under the heading *H*. The lengths of the remaining nine ordinates follow in order.

For short spans, say about 30 feet, it is most convenient to divide the base of the curve into five spaces, as it is the usual practice to give ordinates about every 3 feet. In this case we would use only every other ordinate in the tables, or, beginning with the left-hand column, the ordinates would be as found in the columns headed *H*, 8, 6, 4, and 2.

The construction of the parabolic curve, while familiar to every student of geometry, may be of interest in this connection. In Fig. 2, divide the base *BO* and the height *H* into the same number of equal parts (ten in the illustration); draw straight lines from *O* to points 1, 2, 3, etc., on line *AB*; then draw vertical lines from points 1, 2, 3, etc., on line *BO*. The points of intersection between the lines 1 and 1, 2 and 2, etc., are points on the curve of the parabola. When the curve is slight, as is frequently the case in plain girder design, it is sufficient, on the drawing, to join the points by straight lines.

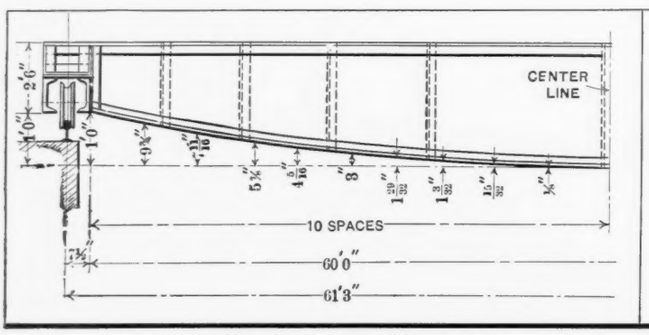


Fig. 1. General Lay-out of Typical Crane Girder

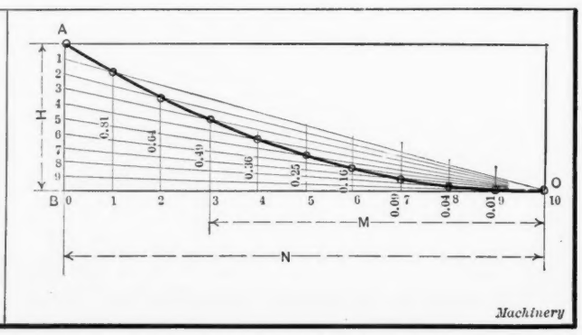


Fig. 2. Lay-out of Parabolic Curve, and Method of Calculating Tables

The tables in the Data Sheet Supplement are calculated as follows. In Fig. 2, let

H = end ordinate,
X = required ordinate,
N = number of equal spaces into which base BO is divided,
M = number of spaces from O to required ordinate.

Then,

$$X = H \times \frac{M^2}{N^2}$$

When $N = 10$, as in the case for which the tables are calculated, $N^2 = 100$, and

$$X = H \times 0.01\, M^2$$

Hence, ordinate No. 2 equals $H \times 0.01 \times 64 = 0.64\, H$. Ordinate No. 6 equals $H \times 0.01 \times 16 = 0.16\, H$, and so forth.

* With Data Sheet Supplement.
† See also MACHINERY, January, 1912, engineering edition, "Points in Crane Construction and Design," and the articles there referred to.
‡ Address: 1809 N. 16th St., Philadelphia, Pa.

MAKING THE "UNIVERSAL" HACK-SAW BLADE

By CHESTER L. LUCAS*

The steel from which hack-saw blades are made is almost invariably a special grade of crucible steel, each maker having a preference for his own particular brand, the content of which he considers best for hack-saw blades. In making the "Universal" hack-saw blade at the West Haven Mfg. Co., New Haven, Conn., the steel comes to the factory in large sheets, and the first operation consists in cutting these sheets to smaller sections, each of which is wide enough to be cut

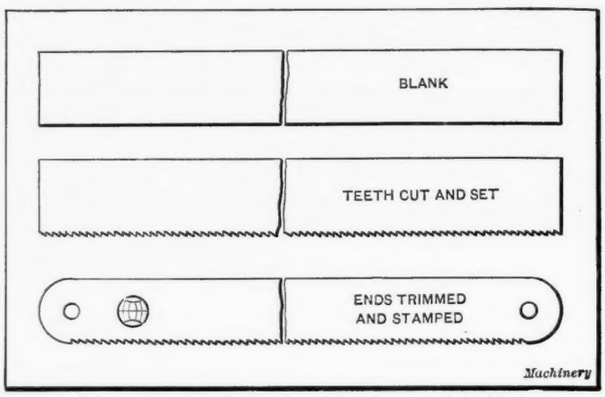


Fig. 1. Order of Operations in Hack-saw Blade Making

into blades of standard lengths, eight, ten or twelve inches. These sections are then cut into blanks for the individual saw-blades. The thickness of the stock and the width of the blank vary, of course, with the different lengths of blades being made. All of this cutting is done on square shears and it is essential that the shear-blades be kept in excellent condition so that the edges of the blanks will be square and free from burrs.

Cutting the Teeth

The blanks for the hack-saw blades are now in the condition shown in the upper view of Fig. 1, being merely blocked to size. Next in order comes the operation of cutting the teeth. Among hack-saw blades makers there are two distinct methods of cutting the teeth; by punching and by milling. The milled tooth is superior to the punched tooth, because milling leaves the sides and faces of the teeth perfectly sharp, while punching rounds one side of the tooth, thus impairing its cutting qualities.

Fig. 2 shows the operation of milling the teeth of "Universal" hack-saw blades. The work is done in plain milling machines, fitted with special vises for holding the thin blades, having "hold-downs" for the front jaws. The vise on the machine shown at the right is but partly filled with blanks, while the one at the left is completely full, and a cut is being taken across the work. The mirror-like appearance of the work is caused by the flooding of the oil over the work. The gang cutters used are made of high-speed steel, and it requires twelve or fourteen of them to make up the width necessary for the average cut. It will be noticed that in

* Associate Editor of MACHINERY.

mounting the cutters on the arbor, they are set one a little ahead of the preceding one, thus effecting a helical arrangement of the faces, the object being to distribute the cut.

These cutters are, of course, made for milling the various sizes of teeth. The number of teeth per inch varies from 14 to 32. Blades intended for cutting solids in iron and steel

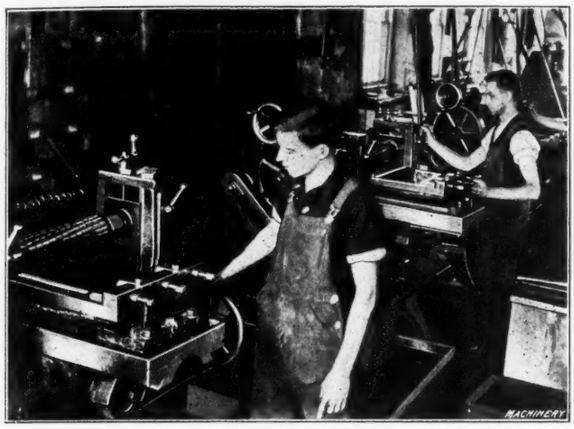


Fig. 2. Milling the Teeth

are usually cut with from 14 to 16 teeth; for general all-around work it is considered advisable to use 20 teeth. For soft brass, 24 teeth has been found better than a smaller number per inch, because there is less tendency to "hog in" and for thin tubing and sheet metal 32 teeth per inch is very satisfactory.

Setting the Teeth

The semi-completed hack-saw blade now appears as shown in the middle view of Fig. 1, and in this condition is ready

Fig. 3. Setting the Teeth

for the setting operation. There are two recognized methods of setting the teeth of hack-saw blades: one is by flat dies having a reciprocating motion, and the other, by rolls having a rotary motion. The machine shown in Fig. 3 is of the rotary type, and as the blades pass between the rolls, projections press the teeth alternately slightly upward and downward, thus giving the teeth the required "set." From the setting machines, the blades are passed to presses that clip the ends, punch the holes, and imprint the trademark upon one end. One of these presses may be seen in the foreground of Fig. 4, and in the background of the same illustration may be seen a battery of the milling machines that cut the teeth.

Hardening and Tempering

The hardening department of the West Haven Mfg Co. is located in a brick addition to the main factory and is exceptionally light and roomy for a department of this kind. The blades are treated by a special process that leaves them as hard as glass, and of extremely uniform hardness throughout.

In order to give them the required toughness, the blades are next tempered by immersing them in hot oil. Previous to this, however, they are packed loosely in an iron frame, similar to the vise used in milling the teeth. This frame has set-screws for applying pressure to the blades, against both the sides and edges. After placing the blades in the frame, and immersing frame and blades in the oil, they are allowed to remain there until the mass of blades has been brought to the temperature of the oil. After this, the screws of the frame are tightened upon the blades, thus bringing any that are bent or warped back into shape. It should be

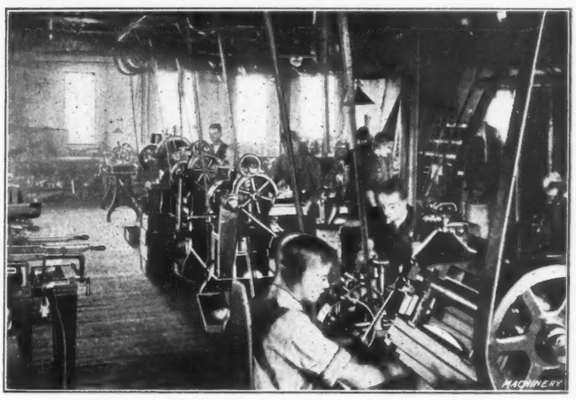


Fig. 4. Milling and Punching Operations

remembered that this is done while the blades are very hot and still dripping with oil, in which condition they yield readily to the pressure from the clamping screws. The hack-saw blades are allowed to remain in the frame until they are cold, at which time those that were warped will have regained their original straight condition.

In order to reduce the brittleness of the pierced ends of the blades, the ends are dipped into a pot of molten lead. The lead in the pot is of the right depth so that when the bottom is touched, the ends of the blades will be immersed to the right distance. After this operation, the blades are cleaned and brushed free from scale and dirt, at which time they are ready for inspecting and packing.

Inspecting and Packing

Fig. 6 gives a general idea of the way in which "Universal" hack-saw blades are inspected and packed. The in-

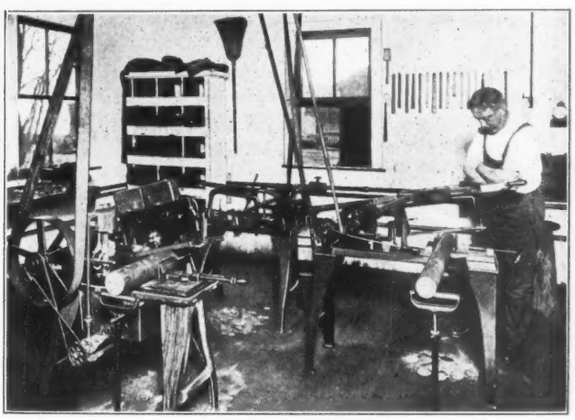


Fig. 5. The Testing Room

spectors sit at well-lighted benches and successively try each saw for temper, at the same time inspecting them for poorly cut teeth and for soft spots that may be present. They are then wrapped in packages of twelve each, labeled and boxed for shipment.

From time to time, blades are selected at random from the different lots and tested for cutting qualities, after the manner shown in Fig. 5. They are tested for duration, for speed in cutting and for performances on various hard metals. The

Fig. 6. Inspecting and Packing

results of these tests are carefully recorded and thus the high standard aimed at in making "Universal" hack-saw blades is maintained.

* * *

INDUSTRIAL ADVANTAGES OF THE UNITED STATES

In the United States—a young, growing country—there has been, and still is, an unlimited demand for more highly developed industries. New manufacturing establishments are constantly under construction, and are usually equipped in the most modern manner. In Europe it is, with few exceptions, merely a case of remodeling old establishments. It is very easily understood that an old remodeled factory can never come up to the same standard or offer the same possibilities for manufacturing, as an establishment which from the beginning is planned after modern ideas. The familiarity with old established ways also tends to make difficult departing from old ideas and moving into new fields. The expense account is also a very important factor and should not be overlooked. Whereas a new shop will cost almost as much with an equipment partly copied after old ideas, as it would equipped in the most modern way, the old shop, modernized to the same extent, would have to stand the expense not only of the modern equipment, but of the old superseded one also. New buildings would in most cases have to precede the new equipment, as the facilities offered by old buildings are often so inferior as to make only half a success of the new departure.

The extent and population of the country makes the home market offered in the United States very large, as compared with the market available to the manufacturer in an average European country. This, in turn, makes possible a greater sub-division of labor. Even the smallest article can be manufactured on a large scale without looking for a market outside of the boundaries of the home country. In Europe, on the other hand, most firms of any importance have been, at least until a very recent date, compelled to go into a number of different lines of manufacture, as each line alone has an insufficient market to make the business pay the desired returns. This is a consideration of more than ordinary importance. Not only can an establishment manufacturing one article or one line of articles, secure a greater prestige in this certain line, and enable its responsible heads to gain a much greater experience in the particular line of work they have to direct, but a systematic arrangement of the work can be established, which is not possible in an establishment manufacturing many varied articles. This sub-division of labor, in the whole industrial field, as well as in the individual shops, has been the great cause of the systematic organization peculiar to American factories. This systematic arrangement, again, has made it possible for American shops to turn out, with the same number of men, a much greater amount of work in a given time than is usually turned out by the average European shop.—*From an address by Mr. A. L. Valentine, of Hartford, Conn., before the American Society of Swedish Engineers, Brooklyn, N. Y.*

* * *

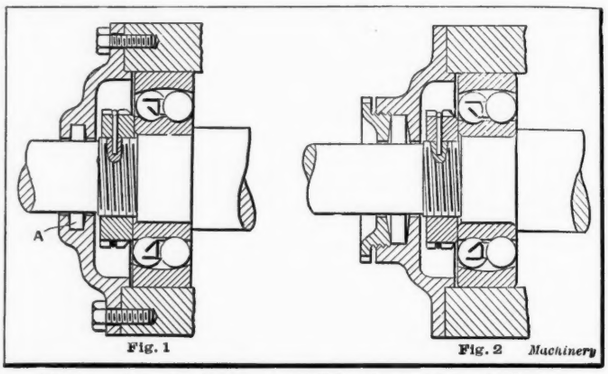
There is a distinction that makes a big difference between a smooth cutting file and a slick one.

THE MOUNTING OF BALL BEARINGS*

By F. H. POOR†

The method used for housing a ball bearing depends largely upon the nature of the machine to which the bearing is applied and the load and speed under which it is operated. One essential should always be kept in mind—ball bearings should in every case be kept clean, in order to give the best service. The selection of bearing caps for any given machine, therefore resolves itself practically into providing for sufficient protection of the bearings against grit or liquids which may be injurious to the bearing, and preventing the escape of the lubricant. The forms of end caps illustrated in the accompanying engravings have been designed for use in connection with the S. K. F. radial ball bearings and have been found satisfactory for general application.

The use of a single groove at *A*, as shown in Fig. 1, is generally sufficient. The grooves are cored to a depth of not less



Figs. 1 and 2. Cap Designs for Ball Bearings with Single Groove

than ⅜ inch and the edges of the lips are bored approximately 1/64 inch larger than the shaft. The width of the grooves and the lips must be determined with a view of providing sufficient strength and protection against abuse when installed. The use of a second groove in the end cap, as shown in Fig. 3, and sometimes a third groove, is recommended where machines are subjected to a great deal of dust, fine grit, moisture, etc. In this case it is customary to pack the outer groove with a felt washer or with a heavy grease, which will provide a frictionless packing. The groove for the felt

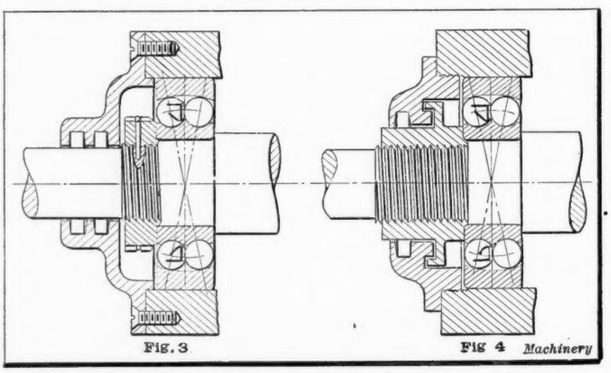


Fig. 3. Cap with Two Grooves. Fig. 4. Cap Design used where Bearing is exposed to Fine Dust

should be machine-finished. The groove adjacent to the bearing may be drained at the bottom to more effectually provide against leakage of the bearing lubricant. The return drain serves to keep the lubricant in circulation behind the sealing groove.

Caps of the type shown in Fig. 4 are too expensive to be considered except for extreme conditions, such as are found in high-speed grinders, cement machinery, etc., where protection against exceedingly fine dust is of importance. Fig. 2 shows a type of end cap, providing for a felt washer only, but

* For further information on ball bearings, see the following articles previously published in MACHINERY: "Some Notes on Ball Bearings," May, 1909, engineering edition, and also the articles there referred to. See also MACHINERY'S Reference Book No. 56, "Ball Bearings."

† Address: Care of SKF Ball Bearing Co., 50 Church St., New York.

having a tightening device to insure a tight fit of the washer on the shaft. This arrangement is applicable to low-speed bearings and is frequently used in automobile transmissions. In Fig. 5 is shown a plain end cap. Numerous means are used for securing the caps to the housings, and also for locking the retaining nut for the inner races. The G-shaped wire shown applied in the engravings, however, is generally considered the simplest form of locking device.

The fitting of bearings to shafts seldom presents any great difficulties. Inasmuch as the bearings are ground to very

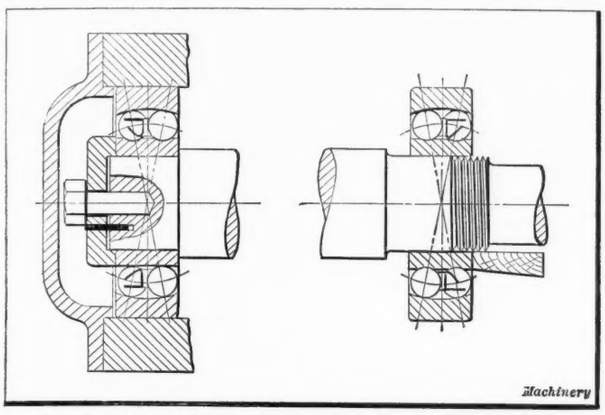


Fig. 5. Plain End Cap. Fig. 6. Using a Piece of Wood to drive Bearing into Place

close limits, the shafts to which they are to be fitted should also be accurately finished to present a smooth uniform seat for the bearing. The inner race should be a tight fit on the shaft and should be permanently seated in a fixed position against a shoulder on the shaft by means of a lock-nut or a distance piece. A driving fit alone should not be depended upon to properly retain the inner race in position, as the continued action of the load on the bearing will tend to peen down the shaft. A positive means for holding the inner race in position prevents creeping on the shaft and materially increases the actual bearing length on the shaft.

In order to obtain a proper light drive fit on the shaft, this should be finished slightly larger than the bore of the bearing, preferably within a maximum limit of 0.001 inch and a minimum limit of 0.0004 inch above the actual size of the hole in the bearing. If the shaft is made smaller, the bearing race will tend to creep and cut into the shaft, and if larger limits than indicated above are allowed, too great a force will be required to properly seat the bearing, with the added danger of cracking the inner race. It is easy to drive the race in place by heating it in oil to about 170 degrees F.

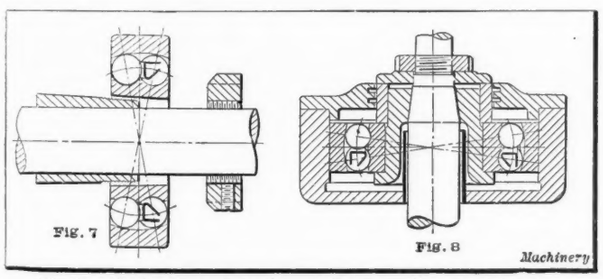


Fig. 7. Adapter Type of Bearing. Fig. 8. Method for Retaining Lubricant in Vertical Bearing Shaft

and driving it into position by light blows of a soft metal hammer. A piece of copper tubing, or a piece of wood in conjunction with an ordinary hammer can also be used for the same purpose, as indicated in Fig. 6. The outer race must under no circumstances be given a blow when fitting the bearing onto the shaft.

The outer race should have a very close sliding fit, but should never be securely fixed in the housing. A slow creeping of the race should at all times be possible under the vibration of the load. This slow intermittent creeping insures a proper distribution of the load over the whole surface of the outer race. Even when it is desired to prevent end motion of the shaft, a slight clearance of 0.010 inch should be provided on each side. Without this lateral clearance—*i. e.*, if the race is securely fixed in the housing—the load will always bear on one position in the race. When there are several radial bearings on the same shaft, one bearing only should be used to hold the shaft against end motion; the outer races of the other bearings should be free to locate themselves.

In cases where it is impossible to make the inner ball race a driving fit on the shaft or to secure it by means of a lock-nut or distance piece, the adapter type of bearing shown in Fig. 7 should be used. This bearing is provided with a conical split sleeve and lock-nut which clamps the bearing on the shaft in any desired position.

The shaft and housing should be turned as true as possible to insure concentric running of the races, and in case split housings are found desirable, great care should be taken to see that the housing sections do not bind the outer races and distort them. The application of radial bearings to vertical shafts occasionally makes lubrication difficult. A practical method of meeting these conditions—as they are sometimes to be found in the upper bearings of sugar centrifugals, vacuum cleaners, side cutters on wood planers, vertical pumps, etc.—is shown in Fig. 8, the retention of the lubricant being amply provided for by the tubular cup between the shaft and the seat for the inner race. This mounting is also made in a modified form with a lock-nut below the bearing, in which case the upper face of the inner race is held against a shoulder on the bearing support.

When it is necessary to use a thrust bearing to take the weight of a vertical shaft, a combination of radial and thrust bearings, as shown in Fig. 9, provides an ideal method of

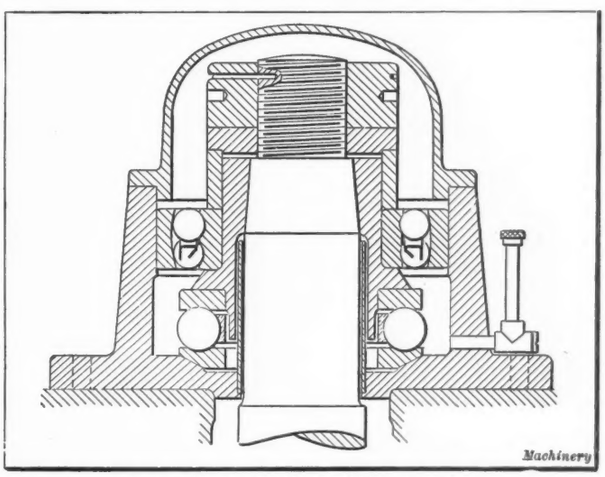


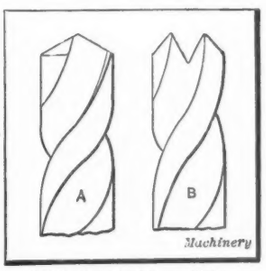
Fig. 9. Combined Radial and Thrust Bearing

mounting. The center of the radial bearing coincides here with the center of the spherical surface of the thrust disk. This provides a combination which is self-aligning about one point.

* * *

THE DRILLING OF MARBLE OR SLATE SLABS

Anyone who has had to drill marble or slate knows of the difficulties met with. Frequently holes are produced by drilling through with a small diameter drill, following with one of the full diameter of the hole required. A better method, says the *Practical Engineer* (London), is to mark out the center of the hole required and start it with an ordinary ¼ inch twist drill, as shown at *A* in the accompanying illustration, replacing this tool by a special tool, as shown at *B* (of the same diameter as that at *A*), as soon as the cavity is deep enough to permit of changing with safety. Then, to obtain the full diameter hole, a drill of the full size required is used as before. This method is more rapid than to drill a small hole right through the marble by an ordinary twist drill.



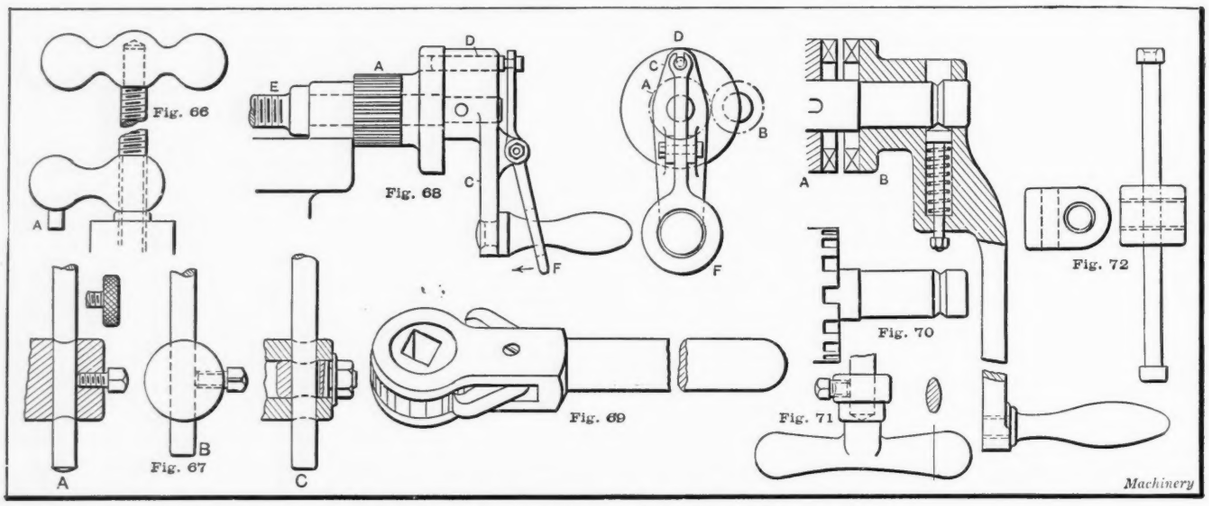
Drills for Marble or Slate

MACHINE HANDLES—2

A STUDY OF THE VARIOUS TYPES OF HANDLES AND HANDWHEELS USED ON MACHINE TOOLS

By FRED HORNER*

The handles and handwheels illustrated and described in the previous installment of this article were, in general, of a simple nature. In the present installment some of the handles and mechanisms described will be of a more complicated nature, including combinations of handles, handwheels, ratchets, indexes, and other similar mechanisms.

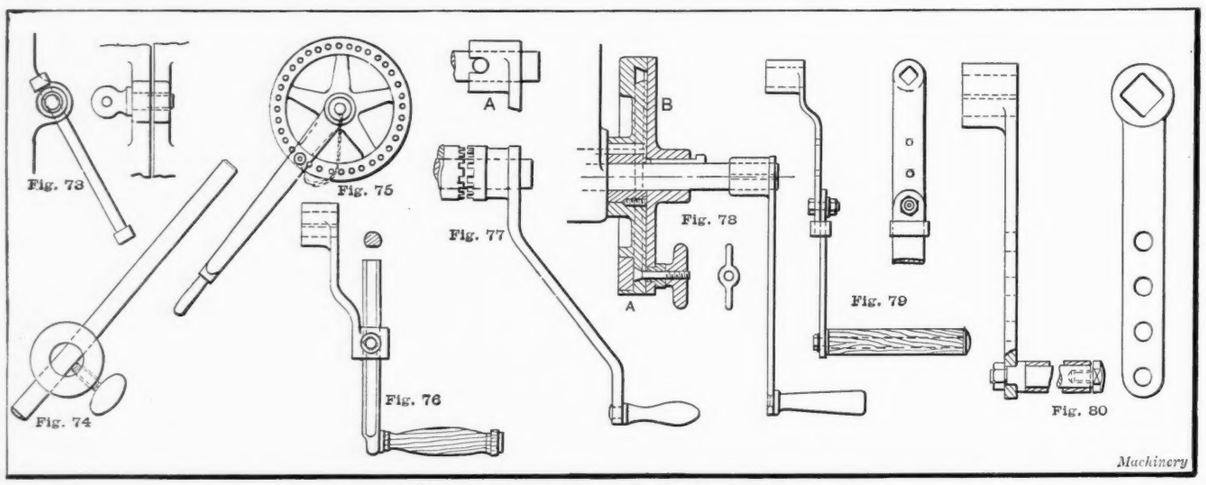


Figs. 66 to 72. Types of Handles used in Machine Tool Construction

In Fig. 66 is shown an example of a handle combining the double and single types, one being used for adjusting the raising screw and the other for locking it. The latter has a small pin *A* which catches against the bearing cap and prevents the handle from swinging into contact with the revolving spur gears on the other side of the cap. A handle attached to the end of a spindle for operating a belt-shifting mechanism for a small countershaft, is shown in Fig. 71. This handle is made of cast iron.

In a few instances, it is not desirable or may be impracticable to permit the handle to project out on one side or the other of its boss. In such a case, a sliding handle of the type shown in Fig. 73 is used; the same kind of handle, passing through a nut on one side of the threaded hole, is shown in Fig. 72. This example is taken from a brass finisher's lathe and is used for tightening the screw of the hand-rest underneath the bed.

Handles provided with clutches, apart from the friction devices already described in the previous installment, are sometimes required to prevent their being operated when the power feed is in and the shaft is rotating. Teeth are cut on the boss or hub of the handle and on the sleeve of the spindle, as shown in Fig. 77, thus permitting of disengagement when desired. Ratchet teeth are occasionally required. As an alternative design, a pin may be driven through the spindle and the hub of the handle may be provided with slots on either side as shown in the detail view at *A* in Fig. 77. Often the handle is kept out of engagement by a weak spring. A washer may be held on the end of the spindle by a set-screw to prevent the handle from falling off, while, in other instances, the washer is omitted in order that the handle may be slipped off and placed on another adjacent screw or spindle. An example of this type of handle is shown in Fig. 70, where two screws or spindles on a boring mill are shown placed close together, and one handle serves for both. The clutch arrangement, in this case, differs somewhat from the ordinary type. The clutch *A* is double-ended, one end only being shown in the engraving, and slides along a feather key on the spindle. When moved to the left it engages with a power-driven clutch gear, but when moved to the right it meshes with the teeth of handle *B*, and the turning of the latter rotates the spindle when an adjustment is desired. The spring plunger in the handle engages with the V-groove in the spindle and prevents the handle from falling off endwise. The spring, however, is not strong enough to prevent the pulling off of the handle when it is desired to remove it.



Figs. 73 to 80. Types of Handles used in Machine Tool Construction

Pilot or star handles, of the types shown in the previous installment, are generally so designed that they can be disconnected so that when the power feed is in action the star handle does not rotate. Some form of friction clutch is usually provided, or a spring plunger is fitted to the hub of the star wheel handle, the plunger passing through into a hole in the sleeve which rotates with the operating spindle

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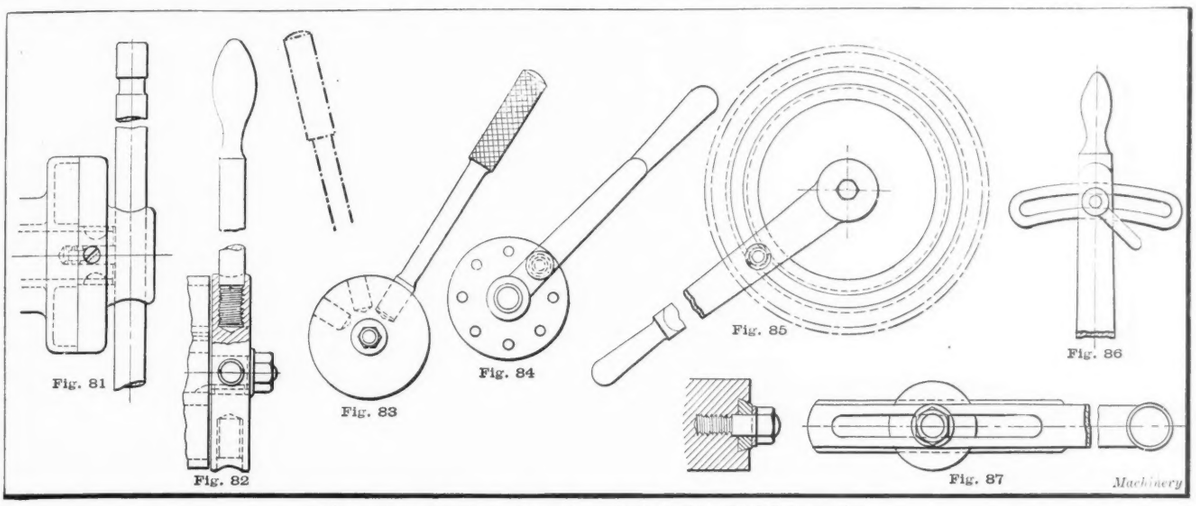
or shaft. The friction-disk device is also a favored type of connecting medium for many mechanisms of this description. The Lang disk device was one of the first to be applied extensively in turret lathes. One of these applications is seen in Fig. 78, in which the power-driven plate *A* is coupled to the disk *B* on the shaft when the wing-nut is tightened.

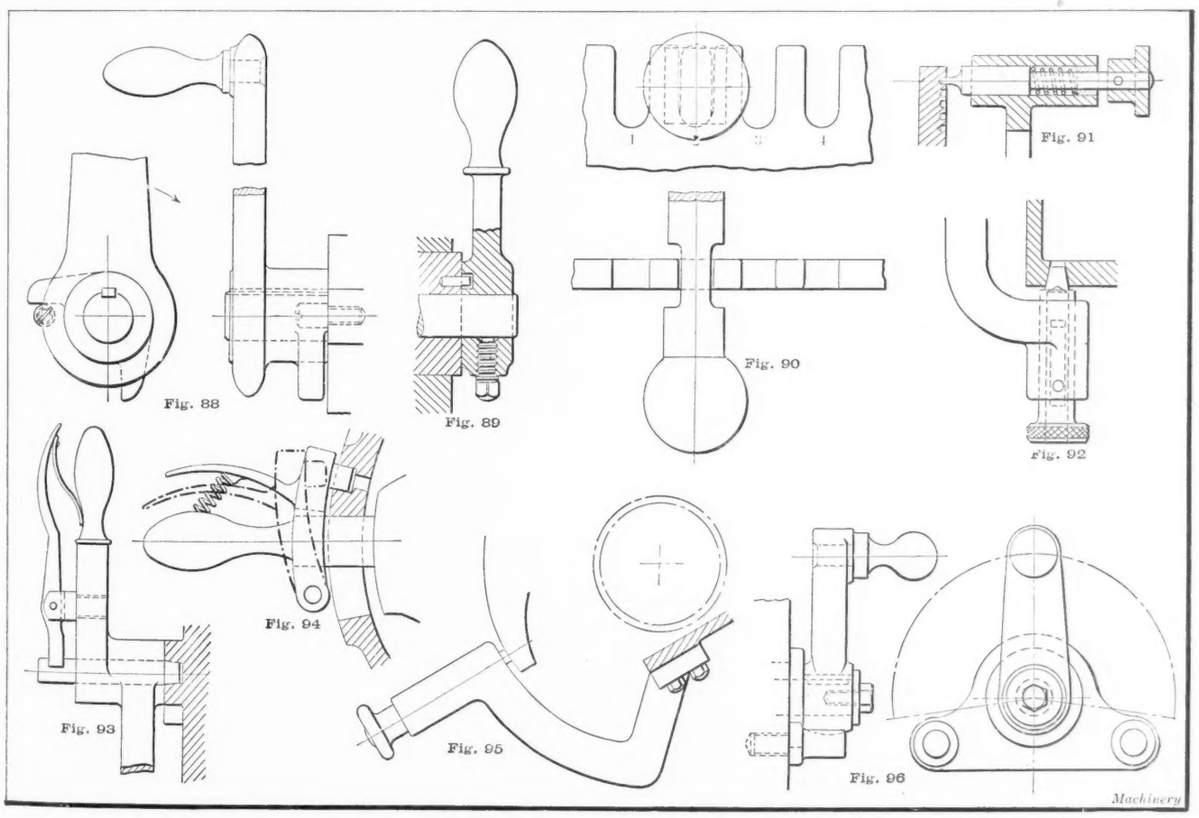


Figs. 81 to 87. Types of Handles used in Machine Tool Construction

Two of these nuts are used when the drive is heavy. Many variations in the details are found in different designs.

Ratchet handles are employed principally for two reasons: either because there is insufficient space for a complete turn of the handle, or because the power required cannot be conveniently applied by a full circular motion of the hand. Most cases of this kind relate to movements where only occasional adjustments are required, such as the adjustment of a slide at infrequent intervals, etc. Such cases occur when the setting lasts for a long period of machining, or when a power feed is usually applied, and the handle is required only to give a small adjustment for exact position. Heavy lathe carriages, for instances, are sometimes operated in this manner and also the saddles and slides for heavy boring and drilling machines. The ratchet is usually double-acting, as shown in Fig. 69, so as to admit of adjustment in either direction without removing it from the square on the end of the screw or spindle.

Another class of handles is designed to enable two or more rates of speed to be obtained, this being accomplished by the withdrawal of a pin or other means of coupling. Many feeds on drilling machines are constructed in this manner so that by a slight movement of a pivoted handle the rapid lever movement is changed into a slow one, by means of a worm or other mechanism for fine adjustment or feed. The application of this device is illustrated in Fig. 68, this being applied to a shaper and actuating the saddle screw. When the parts are in the position indicated, gear *A*, driven by gear *B*, is coupled to the handle *C* by means of the plunger *D*, and screw *E* is rotated by power; but when the hand is applied to the handle, pushing the pivoted lever *F* in the direction of the arrow, the pin *D* is withdrawn and screw *E* may be revolved rapidly by hand.



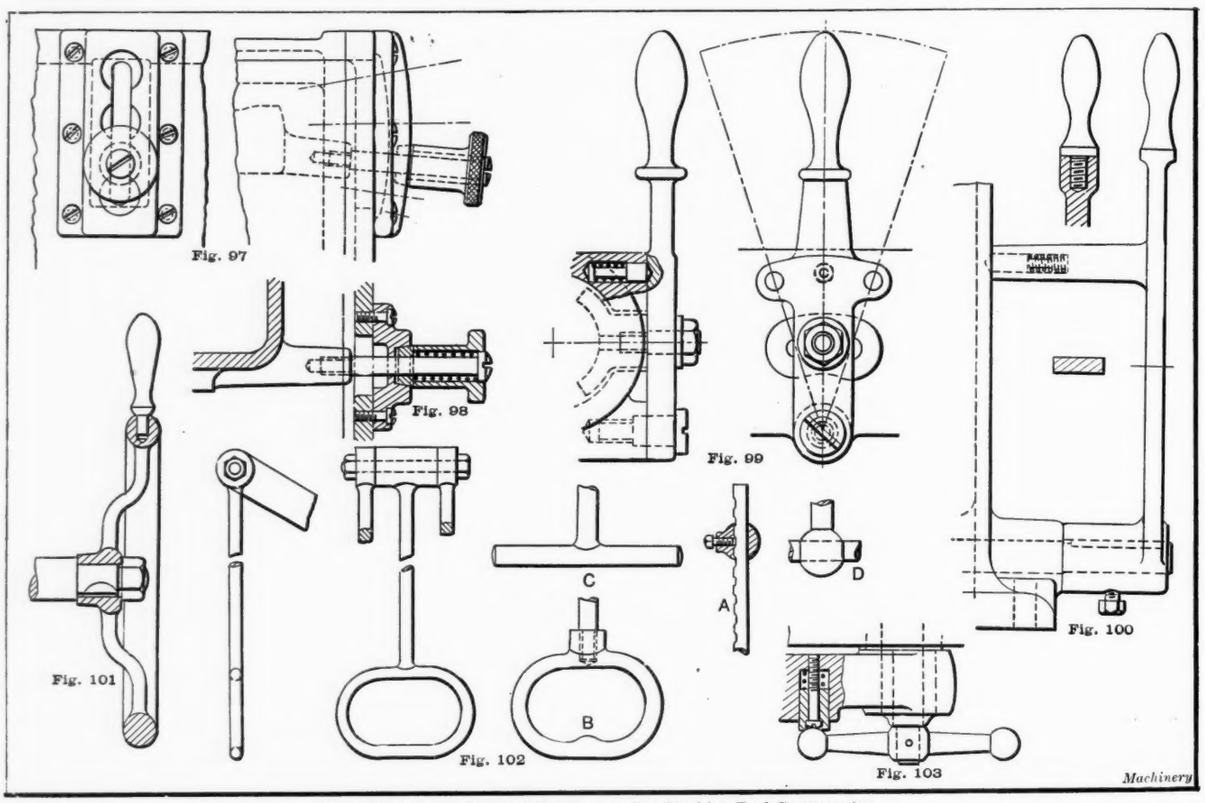
Figs. 88 to 96. Types of Handles used in Machine Tool Construction

Certain types of machines, especially for tapping, are pro-

vided with a simple means for obtaining two speeds, by having two squared spindles for receiving the operating handle. When the handle is applied to one, the drive is at a rapid rate, but when operating upon the other, the drive is through two spur gears at the slow speed. Then there is another common type, that adjustable for radius to suit different powers and speeds. Hand screw machines are very commonly provided with adjustable handles, and so are certain types of portable machines for drilling, planing, shaping, etc. Adjustment for radius is necessary in many handles for feed motions, principally in drilling machines, where a light pressure is more easily applied with a short handle, and a heavy pressure when the handle is drawn out to its full length. The lengths of handles are varied in different ways. A common method is to slide a loose handle through the socket portion which fits on the shaft, as indicated in Fig. 76. This loose portion is then tightened with a set-screw. Occasionally, a split hub is employed instead, and clamped with a set-screw. Another way is that shown in Fig. 79, where flat arms are used, provided with holes for the reception of a tightening bolt. The two parts are also kept together by a loop as indicated. Instead of the separate holes, a slot is sometimes made so that the readjustment may be effected without removing the bolt. In Fig. 87 is shown an instance of an adjustable handle applied to a keyway cutter of the portable type. The dovetail section of the lever prevents it from falling out when the nut is loosened. The handle in Fig. 80, from a portable cylinder boring machine, shows a case where the handle proper is adjusted along the web by a series of holes drilled at different radii. A continuous slot forms an alternative to the separate holes, if more rapid changes are desirable.

The handles for feeding spindles of small drilling machines, etc., are usually of plain bar section and can slide through the boss of the rack spindle. The method of clamping these handles and the means for adjustment are shown in Fig. 67. At *A* and *B* are shown arrangements with set-screws, with either square or knurled heads, and at *C* a grip-bolt design. A wing-screw, as shown in Fig. 74, is also often used. In some sensitive drilling machines the lever is self-locking in any position, through the medium of a spring plunger, as indicated in Fig. 81. The plunger presses against the handle with sufficient force to hold it by friction.

Another class of designs requires that a lever may be adjusted for radial direction so as to bring it in the most convenient angle for the operator's hand. Handles with split hubs, as already described, are used for this purpose in certain instances, but are not always desirable. A type suitable for small drills is that shown in Fig. 82, where the handle can be screwed into either one of three or four holes in the disk on the pinion spindle. Sometimes the handles fit into a tapered hole, as shown in Fig. 83. Among other methods for obtaining the same ends may be mentioned a circle of holes in a disk, into one of which the spring plunger of the pivoted handle can enter, as shown in Fig. 84. A similar method is adopted in the design shown in Fig. 75, where a large wheel is provided with holes for receiving the locking pin of the handle in any position which happens to be most convenient for feeding the spindle. This design is applied to a special vertical hole grinder. An alternative design is that in Fig. 85, where a T-groove is cut in a circular disk so that the handle can be locked in any position by means of a T-bolt and nut. This design is applied to a multi-spindle drilling machine in which each spindle is fed down independently with its own lever, or, if desired, simultaneously by a shaft (common to all) on one end of which is the wheel seen in Fig. 85. The ratchet lever is used on many drilling machines, the engagement of the pawl with any particular tooth governing the radial setting of the lever.



Figs. 97 to 103. Types of Handles used in Machine Tool Construction

In many cases it is important that means be provided for locking or retaining the handle in a certain position after the movement has been made, so as to keep the adjustment unaltered until a change is again made. This requirement is present in nearly all machine tools. Sometimes the range of movement of the lever is small, and, in such a case, the arrangement shown in Fig. 86 may be used, where the handle is clamped to a quadrant with a wing-nut after the handle is adjusted. A stop arrangement is shown in Fig. 96, where two stop-pins are used to arrest the motion of the small handle at each extreme of its movements. In Fig. 88 is shown another example of preventing a movement beyond a certain point. Here two lugs are provided which come in contact with the head of a screw. Still a different arrangement is shown in Fig. 89, where an annular groove is provided, fitting over the stop-pin, so that the latter arrests the motion of the handle at each end of the slot. Another means

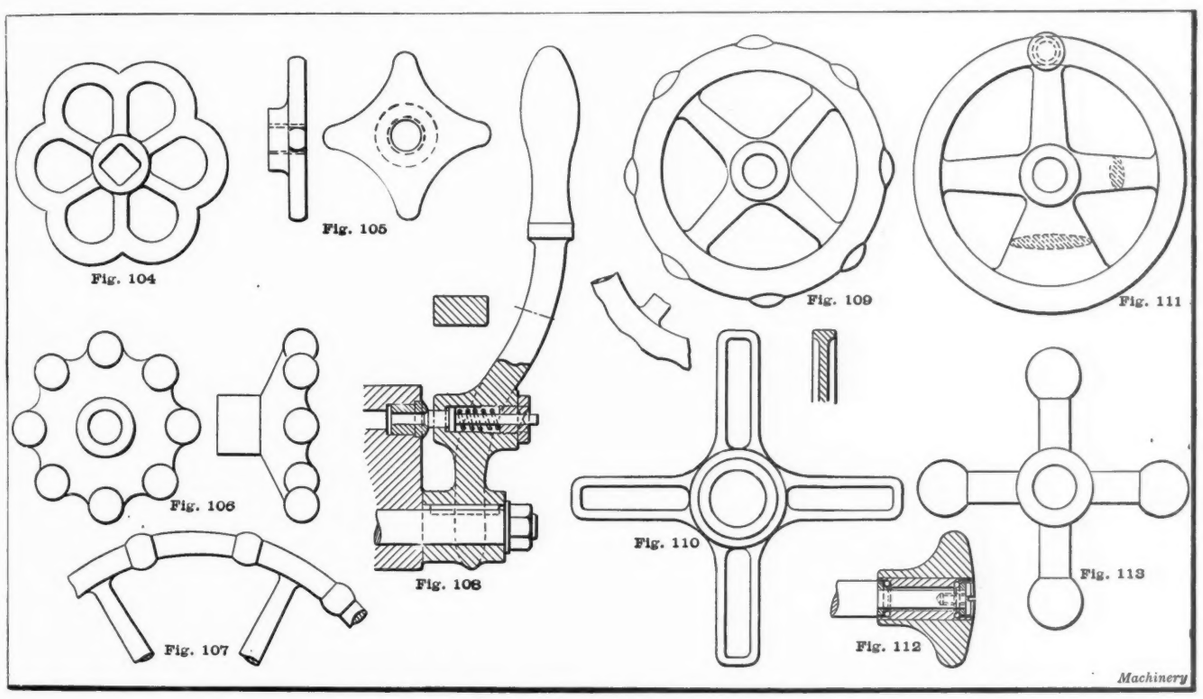
of control is indicated in Fig. 90, where the heavy knob end of a lever is raised, moved to one side and brought into the next notch of the disk.

By far the greater majority of locked handles, however, are retained by some form of spring catch. The spring is combined with a plunger which either acts automatically or is pulled out by hand when making changes, and which maintains the handle steadily in one place and eliminates the vibration which is liable to occur in a locking device without spring action. An example of a hand-operated plunger is shown in Fig. 91, this design being frequently met with on the indexing arm of milling machine dividing heads. Another example, from a milling machine gear-box, is shown in Fig. 92. Here the plunger has a tapered end dropping into a series of holes in the edge of the gear-box. A plunger is often withdrawn by a lever arrangement as shown in Fig. 93. A great many handles are also modeled after the steam-engine reversing lever, with a plunger fitting into notches on the rim of a quadrant or into ratchet teeth on the side of a disk. In Fig. 94 is shown an arrangement used for changing the gears in a gear-box, a pivoted clasp lever being used for withdrawing the plunger, and in Fig. 95 is another example of a handle used for operating gear-box change gears. In Figs. 97 and 98 are shown the elevation, end view and section, respectively, of a handle, the stem of which is screwed into the lug of a tumbler bracket carrying the change gears, and which is locked by the tapered end of the spring handle which enters into the counterbored recesses indicated. The same principle is applied to cases when gears have to be moved laterally, in which case the handles are attached to a forked piece embracing the gear.

The trouble of pulling back the plunger at each change is avoided in a great many handles, by making the plunger end of a pointed or slightly rounded shape, so that it will easily slide out of the countersink provided for it. In Fig. 99 an example of this kind is shown, where a handle can be locked in three positions by a spring plunger. A variation of the design, with the plunger placed in the handle, is shown in Fig. 108. The plunger here slides into a series of hardened steel bushings forced into the casting of the bed of the machine.

If two levers happen to come close to each other, as in the front of a drilling machine gear-box, it is often the practice to carry one handle out further than the other, in order to prevent the handle ends from interfering. The boss of one handle is then lengthened, as shown in Fig. 100, this requiring also the lengthening of the boss that receives the spring plunger. In some cases, the convenience of being able to machine the shaped handle portion separately prompts a design as illustrated in the detail in Fig. 100, where the handle is screwed into the main forged lever. Provision is sometimes incorporated for holding a spring plunger out of engagement with the locking holes, this being usually accomplished by a partial twist which engages a pin in a slot and prevents the forward movement of the plunger. A method of locking a handle in two positions is illustrated in Fig. 103. This method is applied to some milling machine back-gears. The ball ends of the handle are prevented from moving by the hollow spring plunger shown.

Mechanisms which cannot be easily reached by the attendant standing on the ground are either operated by long shafts or chains, or, if circumstances permit, a hanging pull-rod is used, the rod being provided with a loop or handle for the hand. Fig. 102 shows some details used on designs of this kind. The pull-rod is usually made with a boss fitting on the bolt or pin at the end of the levers to which it is attached, and is either of fixed length or adjustable, as indicated at *A*, in which the rod has a series of flats to receive the point of the clamping screw. The handle ends may be designed as shown at *B*, *C* and *D*. If there are two pull-rods close together they are often connected by a loose horizontal link to prevent their clashing with each other, and if a pull-rod comes close to a bearing or spindle, a light bracket is often carried out from the frame to embrace the rod and prevent it from coming into contact with the moving parts.



Figs. 104 to 113. Types of Handwheels and Handles used in Machine Tool Construction

Handwheels

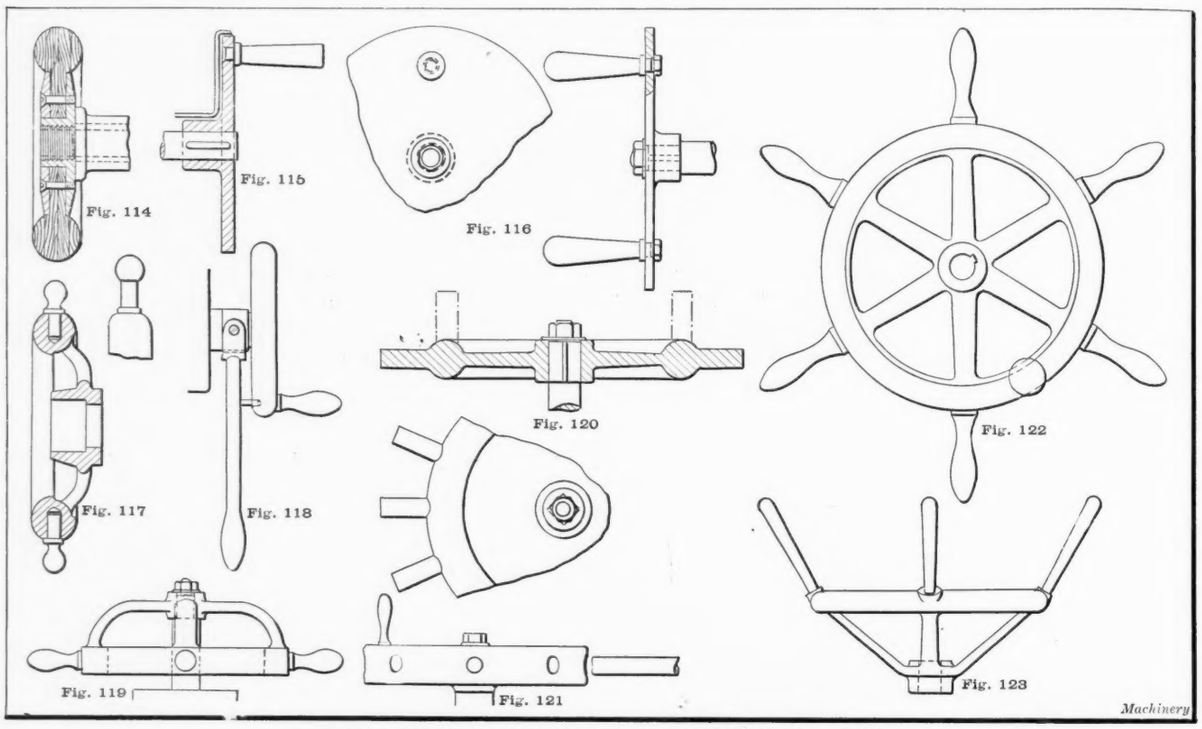
Handwheels are merely a special design of handles; on modern designs the use of handwheels is undoubtedly increasing. The continuous rim of the wheel possesses some advantages which are not present in handles even when made of the star or spider types. The continuous rim always presents something for the operator to grasp without feeling blindly for it in the air, as is often necessary when he has to keep his eye on the work or tools. It also permits of a more delicate feed motion. Micrometer graduations can be placed on a large diameter of the rim. The weight of the rim and its flywheel action are of great advantage when rapidly rotating the wheel for quick adjustments. It is well balanced and does not have a tendency to alter adjustments because of vibration. It can be provided with special fittings, such as dogs, ratchet teeth, feeding devices, and other details. The principal objection to a handwheel is that

it takes up more room than a handle and may, therefore, be in the way. In such cases, it either must be made removable or be discarded for some other design.

On the boundary line between star wheels and handwheels are a number of knobs, cross-handles or disks used chiefly for tightening or clamping where no great power is to be exerted. In Fig. 110 is shown a good example of a cross-handle, and in Fig. 113 another of the ball type. The plain star-shaped knob is often used as shown in Fig. 105, or a small disk with a series of knobs on its periphery, to give a firm grasp, as shown in Fig. 106. The looped type of wheel shown in Fig. 104 is also very popular. Fig. 112 shows a special type of knob fitted with ball-bearings, its function being to control and feed endwise the grinding-wheel spindle of a small grinder. When it is desired to increase the grip of the hands on a handwheel, knobs or projections are often cast on it, as shown in Fig. 109, or the rim may be hollowed out with a series of transverse grooves, as in the small detail shown in the same illustration. Large handwheels are often cast with the rim as shown in Fig. 107. A wooden wheel made in segments as shown in Fig. 114 is very suitable for operating the draw-in chucks on bench and other small lathes.

Handwheels are divisible into two main classes, those which are grasped by the rim only, and those that are fitted with one or more handles projecting either radially or laterally from them. The lateral extending handle is used for rapid rotation, and the radial handle chiefly to enable increased power to be exerted. An example of a wheel provided with a single handle is shown in Fig. 101. The accurate balancing of a handwheel with one handle is often neglected, but sometimes the arm opposite the handle is increased in size so as to balance the wheel properly, as shown in Fig. 111. Wheels of solid disk type, with one or two handles, as shown in Figs. 115 and 116, are easily manufactured and very convenient for certain applications; the edge is often graduated. An increase in the number of radial handles is often necessitated for reasons of convenience, because when provided with two or more handles, one will always be within easy reach. In Fig. 122 is shown a wheel with six radial handles, and one transverse handle on the rim. A peculiar specimen from a German turret lathe is shown in Fig. 124, in which a comparatively small handwheel has handles bolted into it and these handles again have lateral handles riveted to them.

A compromise between the radial and the transverse positions of the handles has sometimes been made, when the conditions prevent a strictly radial setting. Fig. 123 shows an extreme case of this. This wheel is placed horizontally on the bed of a cold-sawing machine so that the operator would have to bend down to reach it. For this reason, the rim is carried upwards by the arms, and handles inserted into it in an angular direction. Another arrangement, with the rim and the handles in a different plane from the boss, is shown in Fig. 119, this being the operating wheel for a vertical forming-slide, where the inside of the wheel can



Figs. 114 to 123. Types of Handwheels used in Machine Tool Construction

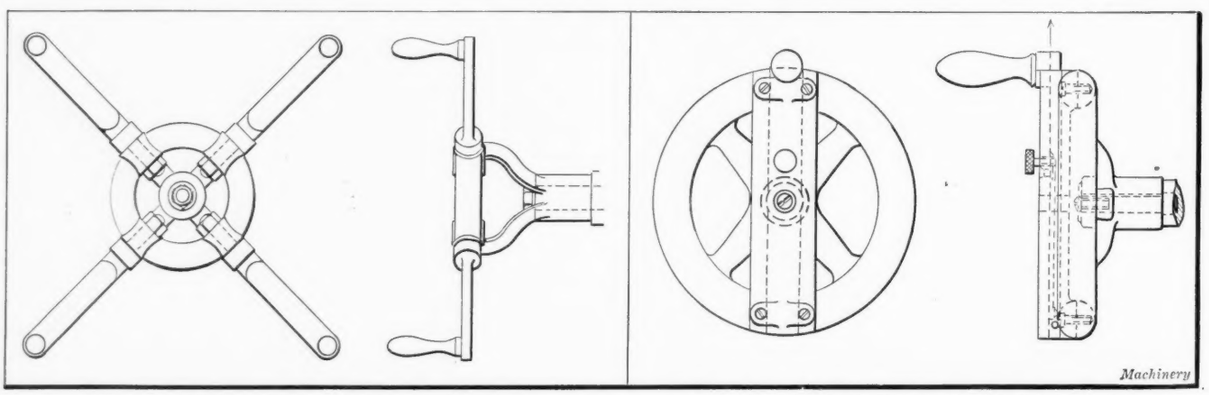


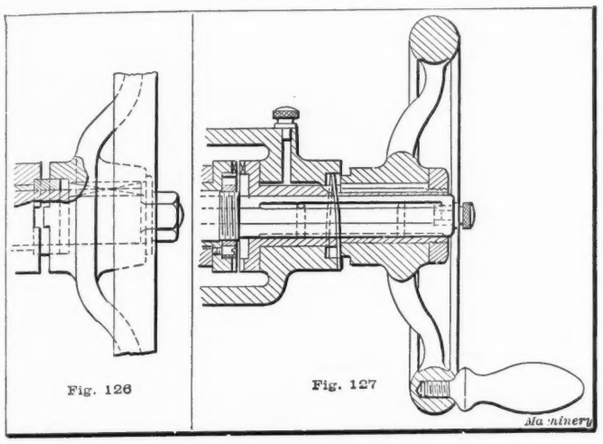
Fig. 124. Handwheel with Radial and Lateral Handles

Fig. 125. Handwheel with Handle Adjustable Radially

pass over the outside of the slide. Sometimes small knobs are fitted to the rim of the handwheel as shown in Fig. 117.

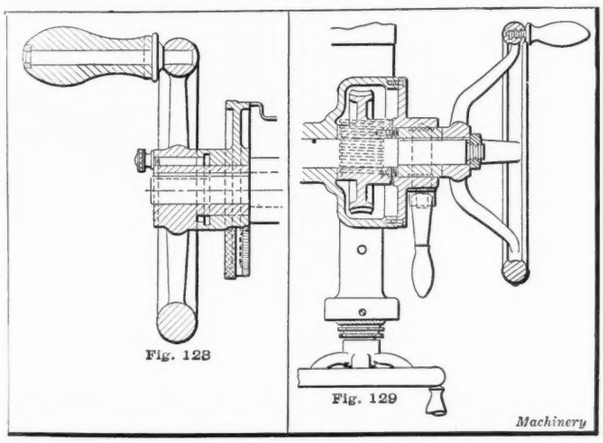
In some cases a considerable increase of power over that ordinarily required may be necessary at intervals. This condition is met in a German turret lathe by the arrangement shown in Fig. 118, where a lever pivoted on a boss adjacent to the hub on the handwheel is provided. This lever can be moved up against the handwheel so that a pin in it engages with the wheel, and a more powerful turning moment is thus obtained at the end of the lever than would be possible at the handle of the wheel.

Certain classes of handwheels made with solid webs instead of arms are provided with a set of holes around the



Figs. 126 and 127. Handwheels with Clutch Arrangement

periphery for the insertion of bars for turning them, as shown in Fig. 121. Another method of attaining the same object is to forge the wheel with a series of short pins or arms extending out from the rim and slip a piece of pipe on either of these for getting the increased leverage. A design of this kind is shown in Fig. 120. Sometimes the pins project out in the direction indicated by the dotted lines, in which case a bar can be laid across the wheel to engage with these pins. Fig. 125 illustrates a more complicated method of design for increasing the leverage of the handwheel, this being applied to certain milling machine table



Figs. 128 and 129. Means for Connecting and Disconnecting Handwheels

handwheels and cam-cutting attachments. The handle is formed with a sliding piece moving in ways screwed onto the wheel, and is pulled out when required.

A great number of devices for coupling and disconnecting handwheels have been designed. A plain clutch hub, as shown in Fig. 126, may have only a couple of teeth on opposite sides of the periphery, although it is more convenient if a greater number of teeth are used, so that the wheel may be slipped into engagement at almost any point. A spring may or may not be incorporated to keep the wheel out of mesh. In Fig. 127 the spring is placed in front of the boss and the resistance of this has to be overcome when the wheel is pushed forward to engage the teeth inside of the casing. Sometimes clutch teeth are provided in both faces of the hub so as to engage different mechanisms when moved toward the right or left.

Friction locks frequently are used in connection with micrometer dials when the dial must be released to turn it to the zero position for a new setting. This is accomplished, as shown in Fig. 128, by a bolt working in a circular T-slot by means of which the micrometer disk can be clamped to the wheel hub. Another method is to use a central threaded pin and let this force a transverse pin upward against the bore of the disk.

In the case of many handle mechanisms, it is necessary to provide for rapid and slow feeds or adjustments, which cannot be done by a single handle or handwheel. The most commonly used method is to use a worm and worm-wheel, the wheel being on the shaft of the rapid handwheel and the worm being turned by another handwheel at right angles to the first, as shown in Fig. 129. Some kind of clutch is incorporated to connect or disconnect the two movements. In the example shown, the rapid handwheel has a clutch moved along by a circular rack in order to engage the worm-wheel.

* * *

PATTERNS FOR THE FOUNDRY

In an address before the Superintendents' and Foremen's Club at Oakley, Cincinnati, Ohio, Mr. H. M. Ramp, superintendent of the Modern Foundry Co., called attention to the difficulties the foundryman has to meet because of the fact that patterns are poorly made or in poor condition. In the course of his address he said that many concerns have inspectors who check up every piece of work done in the factory; some have inspectors who check up every gage and templet at stated periods to discover errors and prevent mistakes; but he knew of no concern that employed an inspector to periodically check up the patterns to find out if they were true. Usually such checking is first done after a lot of castings have been rejected, and only then is the pattern found to be at fault. There seems to be a tendency today to save on pattern cost, although a great deal of money is spent for improved machinery in the machine shop to improve the quality and cheapen the cost of the finished product. The average patterns in the average foundry today are not made as well as they were ten years ago, and still there is a reason why the foundry ought to be supplied with better patterns than formerly. The trend of the times is to reduce the skill of the workers by putting more dependence on improved machinery; hence, the molders of today are not as skilled as they were years ago, and, for that reason, better patterns rather than poorer ought to be the rule.

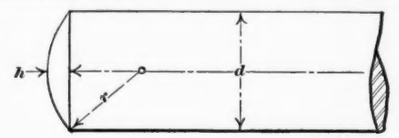
Mr. Ramp also called attention to the lack of understanding of the requirements of the foundry on the part of many machine designers. The castings designed may be perfectly fitted for the purpose for which they are made, but the design is such that the molder cannot make a perfect casting on account of the excessive strains produced by the unequal proportions of the different parts, and it is impossible to prevent these castings from cracking or warping. It is easy enough to say that no more metal is required at this or that point; it may be very creditable to be able to design a machine with a maximum of utility and a minimum of weight, but, nevertheless, there are unalterable laws in the shrinkage or contraction of cast iron that the designer cannot be permitted to overlook. Many castings are designed with a view to saving metal, which, as a matter of fact, will have a higher ultimate cost than if no specific effort to save metal had been made. The extra labor cost in the foundry in such cases outweighs the saving in the cost of the metal.

* * *

Fernand Forest is credited in France as being the first mechanic to construct a multiple-cylinder explosion motor. Forest claims that he built the first four-cylinder motor in 1889, and the first gasoline launch in 1885. He developed magneto ignition in 1883, thirteen years before it was adopted by any automobile manufacturer. A movement is on foot in France to reward Forest for his inventions which are the foundation of the modern internal combustion motor, and for which he received little or no financial benefit.

TABLE OF RADII FOR TOOLS TO TURN SPHERICAL ENDS

(h) in 64ths	Diameter (d) in 32nds																														
	1/16	3/32	1/8	5/32	3/16	7/32	1/4	9/32	5/16	11/32	3/8	13/32	7/16	15/32	1/2	17/32	9/16	19/32	5/8	21/32	11/16	23/32	3/4	25/32	13/16	27/32	7/8	29/32	15/16	31/32	1
	Radius (r)																														
1/64	0.039	5/64	0.133			0.207	17/64	0.332	13/32	0.488	37/64	0.676	25/32	0.894	1 1/64	1.144	1 1/32	1.426	1 37/64	1.738	1 29/32	2.082	2 17/64	2.457	2 21/32	2.863	3 5/64	3.301	3 17/32	3.769	4 1/64
1/32	1/32	0.051	5/64	0.113	5/32	0.151	0.190	15/64	0.284	0.339	0.398	0.464	0.534	39/64	0.690	0.776	0.867	0.964	1.065	1 1/64	1.284	1.461	1.523	1.651	1.784	1 59/64	2.065	2.214	2.367	2.526	2.690
3/64	.....	3/64	0.065	0.089	0.117	0.151	.....	0.189	0.227	0.268	5/16	0.361	0.414	0.471	17/32	0.596	0.664	0.736	13/16	0.893	0.977	1.064	1 5/32	1.252	1.352	1.455	1 9/16	1.674	1.789	1.908	2 1/32
1/16	.....	.....	1/16	0.080	0.102	0.127	5/32	.....	0.195	0.228	0.264	0.303	0.345	25/64	0.439	0.491	0.545	0.603	0.664	0.728	0.795	0.866	0.939	1 1/64	1.095	1.178	1.264	1.353	1.445	1.541	1.639
5/64	.....	.....	.....	5/64	0.095	0.116	0.139	0.166	0.177	0 204	15/64	0.267	0.302	0.340	0.380	0.423	11/32	0.517	0.568	0.621	0.677	0.736	21/32	0.861	0.927	0.996	1.068	1.142	1 7/32	1.298	1.380
3/32	.....	.....	.....	.....	3/32	0.111	0.130	0.152	0.166	0.190	0.215	0.243	0.273	0.306	0.340	0.377	0.417	0.458	0.501	23/64	0.595	0.645	0.698	0.752	0.809	0.868	0.930	0.993	1.059	1.127	1.180
7/64	.....	.....	.....	.....	.....	7/64	0.126	0.145	0.166	0.181	13/64	0.227	0.254	0.282	5/16	0.345	0.379	0.415	29/64	0.493	0.535	0.579	5/8	0.673	0.723	0.774	53/64	0.884	0.941	1.001	1 1/16
1/8	.....	.....	.....	.....	.....	.....	1/8	0.142	0.160	0.181	0.195	0.217	0.240	17/64	0.292	0.321	0.352	0.384	0.417	27/64	0.490	0.529	0.570	0.613	0.657	45/64	0.751	0.800	0.852	0.904	0.959
9/64	.....	.....	.....	.....	.....	.....	.....	9/64	0.157	0.175	0.191	0.210	0.231	0.254	0.278	0.304	0.331	0.360	25/64	0.423	0.456	0.491	0.528	0 566	0.606	0.648	0.691	0.735	25/32	0.829	0.878
5/32	.....	.....	.....	.....	.....	.....	.....	.....	5/32	0.173	0.188	0.206	0.225	0.246	0.268	0.291	0.316	0.342	0.370	0.399	0.430	0.462	0.495	0.530	0.566	0.604	0.643	0.683	0 725	0.768	0.813
11/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	11/64	3/16	0.204	0.221	0.240	0.260	0.282	0.305	0.329	0.354	0.381	0.409	0.438	15/32	0.501	0.534	0.568	0.604	0.641	0.680	0.719	0.760
3/16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13/64	0.219	0.237	0.255	0.275	0.296	0.318	0.342	0.367	0 392	0.419	0.448	0.477	0.508	0.540	0.573	0.607	0 642	0.679	0.717
13/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7/32	0.235	0.252	0.271	0 290	0.311	0.333	0.355	0.379	0.405	0.431	0.458	0.487	0.516	35/64	0.579	0 612	0.646	0.681
7/32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15/64	1/4	0.268	0.286	0.305	0.325	0.347	0.369	0.393	0.417	0.443	0.469	0.497	0.525	0.555	0 58'	0.618	0.651
15/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1/4	0.266	0.283	0.301	0.320	0 340	0.361	0.383	13/32	0.430	0.455	0.481	0.508	0.536	0.564	0.594	9/16
1/4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17/64	0.282	0.299	0 317	0.335	0.355	0.376	0.397	0.420	0.443	0.468	0.493	0.519	0.546	0.574	0.603
17/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9/32	0.297	0.314	0.332	0.351	0.370	25/64	0.412	0 434	0.457	0.481	0.506	13/32	0.558	0.585
9/32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19/64	0.313	0.330	0.347	0.366	0.385	0.405	0.421	0.448	0.471	0.494	0.518	0.544	0.569
19/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5/16	0.328	0.345	0.363	0.381	0.400	0.420	0.441	0.463	0.485	0.508	0.532	0.556
5/16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21/64	0.344	0.361	0.378	0.397	0.416	0.435	0.456	0.477	0.499	0.522	0.545
21/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11/32	0.360	0.376	0.394	0.412	0.431	0.450	0.470	0.491	0.513	0.536
11/32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23/64	3/8	0.392	0.409	0.427	0.446	0.465	0.485	0.506	0.527
23/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3/8	0.390	0.407	0.425	0.443	0.461	0.480	1/2	0.521
3/8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25/64	0.406	0.423	0.440	0.458	0 477	0.496	0.515
25/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13/32	0.422	0.439	0.456	0.473	0.492	0.510
13/32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	27/64	0.438	0.454	0.471	0.489	0.507
27/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7/16	0.453	0.470	0.487	0.504
7/16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29/64	0.469	0.485	0.502
29/64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15/32	0.485	0.501
15/32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	31/64	1/2
1/2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1/2



RADII FOR TOOLS TO TURN SPHERICAL ENDS

By WILLIAM W. JOHNSON*

The method of arriving at the results given in the accompanying table of radii may be of interest. The work was reduced to a minimum in the following manner. The general formula for r in terms of h and d is

$$r = \frac{1}{2}\left(\frac{d^2}{4h} + h\right) \qquad (1)$$

Let $d = \frac{m}{32}$, and $h = \frac{n}{64}$; where

m = the number of 32nds in d, and

n = the number of 64ths in h.

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Then,

$$r = \frac{m^2 + n^2}{128\,n} \text{ or } r = \frac{n}{128} + \frac{1}{n}\left(\frac{m^2}{128}\right) \qquad (2)$$

By means of a table of 1/128ths of an inch, and a table of squares, each column of figures is calculated as follows:

Take for example the column for $\frac{3}{8}$ inch diameter.

$\frac{3}{8} = \frac{12}{32}$, then $m = 12$ and $m^2 = 144$.

Giving n the values 2, 3, 4, 5 and so on, in (2), we have

$$\frac{2}{128} + \frac{1}{2}\left(\frac{144}{128}\right) = \frac{74}{128} = \frac{37}{64} = r.$$

$$\frac{3}{128} + \frac{1}{3}\left(\frac{144}{128}\right) = \frac{51}{128} = 0.3985 = r.$$

$$\frac{4}{128} + \frac{1}{4}\left(\frac{144}{128}\right) = \frac{40}{128} = \frac{5}{16} = r.$$

$$\frac{5}{128} + \frac{1}{5}\left(\frac{144}{128}\right) = 0.0391 + \tfrac{1}{5}\,(1.1250) = 0.0391 + 0.2250 = 0.2641 = r$$

and so on, until $n = 11$.

Then $n = m$, $h = \frac{d}{2} = r$.

* * *

One good way to spend some of your stray thinking moments is in digesting the question of just exactly what it is you are aiming at in the world anyway.

ELECTRIC CONTROLLING DEVICES

By G. J. KIRCHGASSER

Electric controlling devices for electric motors include such apparatus as starting rheostats, speed regulating or controlling rheostats (referred to as speed regulators and controllers), and such devices as compensator or auto-transformer types of motor starting apparatus, which are used for alternating current motors. Besides these, there are special types of switches, such as float and tank switches, magnetically operated switches, star-delta switches used with squirrel cage induction motors, and various other styles used for controlling the motor or the circuit to it. Automatically operated motor starters, regulators and controllers are also included under this heading.

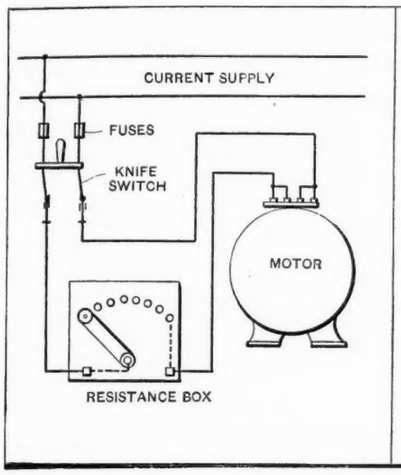

Fig. 1. Resistance Box in Armature Circuit arranged to be cut out by moving Lever over Successive Contact Button Terminals

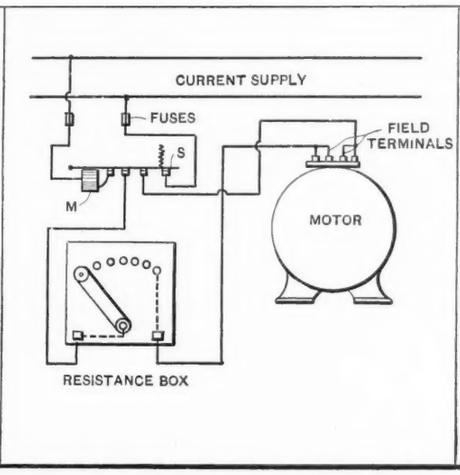

Fig. 2. Diagrammatic View of the Main Features of Shepardson's Patent Magnetically closed Main Line Switch

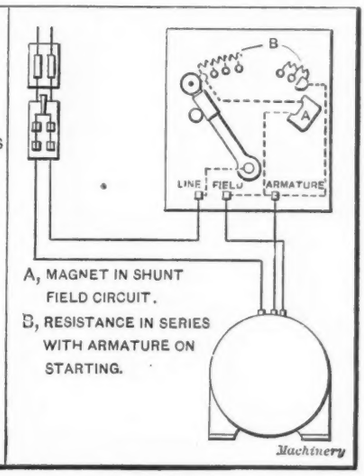

Fig. 3. Blades' Patent Controlling Device having Magnet incorporated with Starting Device and connected in Shunt-field Circuit

The motor with its controlling device can be compared to the human body. The muscles, representing the power, correspond to the motor, and the brain which controls or regulates the working of the muscles, corresponds to the controlling device. Work done by the muscles can be disastrous unless properly controlled, and an electric motor supplied with power is also very apt to cause trouble unless provided with a controlling device of some kind. The wires connecting the controlling device and motor are comparable to the nerves emanating from the brain and passing to the muscles.

A motor of very small power can be started without the need of a starting rheostat, but for most motors used in manufacturing or industrial plants starting or regulating devices of some kind are required.

Action of Motors

Current is passed through the armature conductors of a motor (which are parallel to the shaft) at right angles to the magnetic lines which pass from the motor field poles. The electrical energy transmitted to a motor meets with several losses in changing to mechanical action. If the resistance of the armature conductors is high, there will be a correspondingly high loss in this part of the motor. As the motor armature revolves in a magnetic field, a current is set up in the armature conductors just as in the case of a dynamo. This flows in a direction opposite to the current being fed to the motor and is greater at full speed than at half speed, while at a standstill, of course, no counter current is generated, because the conductors are not moving through a magnetic field. Because of the absence of this counter current or counter electromotive force when a motor is being started, there is nothing to check the inrush of current.

The necessity for controlling devices (of which the motor starter is the pioneer) for use with motors was recognized even before the first commercially efficient motors were put on the market for industrial purposes, which was about 1885. Early motors caused trouble, because it was found that when the switch connecting them to the line was closed, a very large current inrush took place. Controlling devices were not made then, so the armature was built with a high resistance, which served to retard the current inrush during starting; but as this high resistance was in circuit at all times, it resulted in the motor being very inefficient during normal running, and its speed varied considerably under varying load conditions.

One of the chief advantages of the shunt-wound motor is its ability to run at about constant speed even though it be driving two lathes or five, for instance, but the high resistance armature destroys this self-regulating feature, and, therefore, early electrical men tried to invent and design devices or methods for regulating the high resistance armature motor.

Fig. 4. Simple Hand-operated Motor Starting Rheostat with No-voltage Release

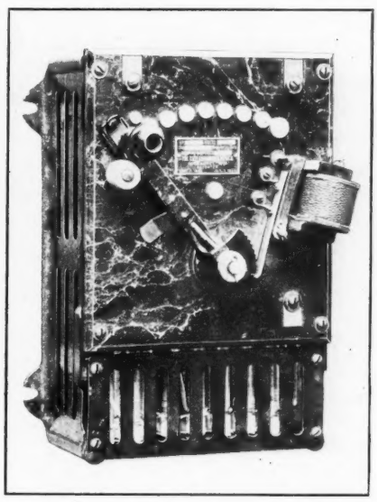

Fig. 5. Small Hand-operated Speed Regulator

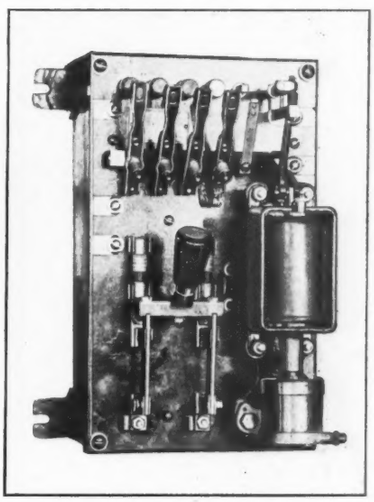

Fig. 6. Simple Automatic Motor Starter, Single Solenoid Type

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No commercially practicable results followed until the armature with low resistance was developed. To avoid the large inrush of current mentioned, a resistance connected so as to be inserted during the starting period and cut out when running was employed. This was set up outside of the motor itself and really was the first controlling device of any value. The low resistance armature motor runs at practically constant speed, and with the arrangement of an outside starting resistance for cutting down the current, it put the high resistance armature motor and the various regulating devices into the scrap heap at one sweep. The diagrammatic sketch, Fig. 1, illustrates the method of inserting the resistance by means of a now obsolete type of starting-box. The lever for cutting out the resistance or returning it to the "off" position had to be moved by hand.

Motor manufacturers began using the shunt motor and this starting-box in which the starting arm was moved from the "off" to the "on," and *vice versa*, by hand. This arrangement, which marked the highest type that the most capable men in the electrical industry at that time were able to devise and place on the market, involved several great dangers: first, due to accidental breaking of the shunt field circuit, resulting in running away and destruction of motor and excessive

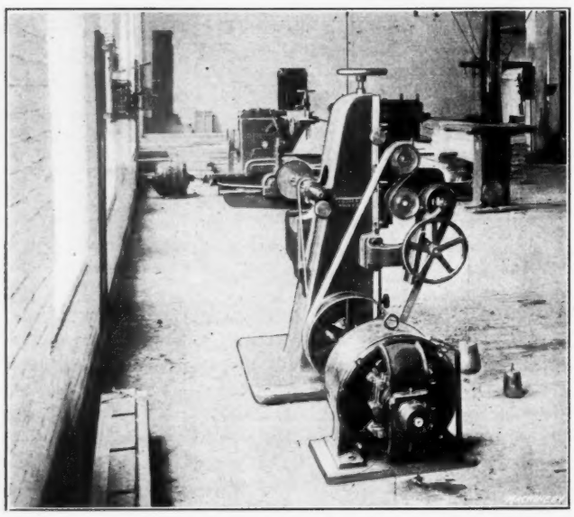


Fig. 7. Motor Starting-box, mounted on Wall for Starting Motor installed on Floor

current in the armature caused by the decreased counter electromotive force generated; second, due to the contact lever not being returned to the "off" position when shutting down, resulting in destructive current when the main switch was thrown in again and in sudden jerk instead of gradual acceleration (just as though no starting rheostat were installed); and third, due to leaving the contact arm on intermediate contacts, resulting in burning out the resistance of the starter.

Besides this, the blowing of the fuse, the cutting off of the current supply, the sudden drop of voltage—all left the motor unprotected, no starting resistance being in circuit when the current was again supplied. It meant that every motor would have to have an attendant to push the operating lever to the starting position when trouble arose, and it should be remembered that in the early days interruptions in current supply, drops in voltage, etc., were of more frequent occurrence than now. The dangers arising from the re-establishment of the current supply after the same had been cut off were a serious menace to the commercial operation of the electric motor. There was a crying need for a controlling device to overcome these dangers.

Shepardson's Main Line Magnetic Switch

Shepardson's main line magnetic switch was an effort to solve the problem, but it did not take care of all requirements. The switch lever *S*, Fig. 2, is held back by a spring so that when the current supply is cut off the magnet *M* is demagnetized, and the switch springs up and opens the circuit to the motor. The motor was not left connected to the line, but an attendant was just as necessary to push the starting lever back, and nothing prevented leaving the lever on an intermediate contact. Also, if the connection to the shunt field opened, there was no provision for opening the circuit automatically to prevent destruction of the motor.

Blades' Controlling Device

The device required, however, was finally invented. It marked the greatest step in the commercial application and operation of the electric motor. The invention, application for patent on which was filed Nov. 30, 1888, by Mr. Harry H. Blades, comprised a shunt motor connected to a constant po-

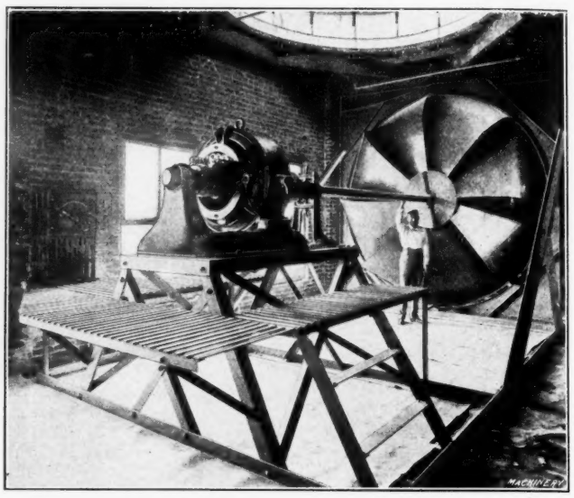


Fig. 8. Ten-foot Fan driven by a 25 H. P., C. & C. Direct-current Motor regulated by a Cutler-Hammer Speed Regulator

tential circuit; a starting-box consisting of a series of resistance steps; a contact arm adapted to be moved by hand over the terminals of the resistance associated with the motor, whereby the resistance may be included in series with the armature of the motor when the contact arm is in the "off"

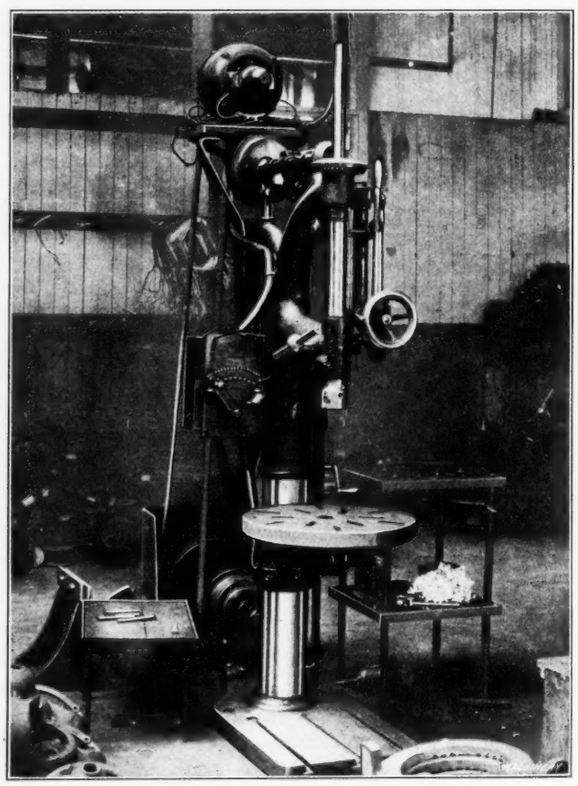


Fig. 8A. Drill Press equipped with Combination Starting and Regulating Rheostat

position, and may be removed entirely from the circuit when the contact arm is in the "on" position; and a magnet which is adapted to grasp and hold the contact arm in the "on" position after it has been moved to the "on" position by hand. This magnet is connected in the shunt field circuit so that it

will not be influenced by varying currents flowing through the armature, but will be influenced only by the current flowing through the shunt field circuit. Fig. 3 illustrates Blades' original structure, patent for which was issued January 7, 1890. Mr. Blades was at that time electrical engineer for the Detroit Motor Co., which company has long since been out of business.

Blades had produced a novel combination for overcoming the dangers incident to the employment of the shunt motor and hand starting-box. If the shunt field were broken, the current supply interrupted or the fuse blown, the motor would shut

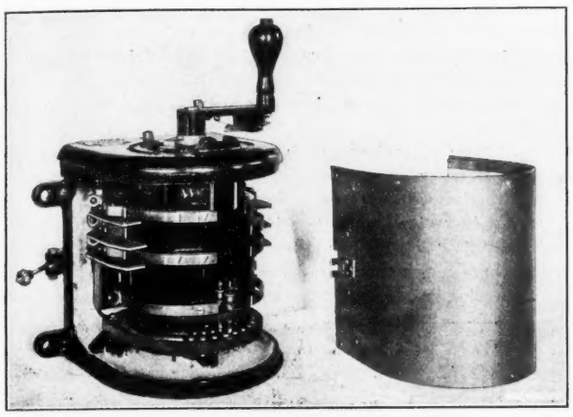


Fig. 9. Drum Type Machine Tool Controller

down with the lever of the starting-box in position for starting properly; if the voltage dropped a trifle and only temporarily, the motor would not be disconnected, but if the drop were prolonged, the motor would be shut down and the rheostat lever returned to the starting position automatically. As there are only two rest positions of the starting lever, "off" and "on," and a strong spring is provided, the danger incident to leaving the lever on an intermediate contact was obviated. About 1892 and 1893 the Blades patent began to be used to a great extent, and by 1896 the use of the automatic release of the

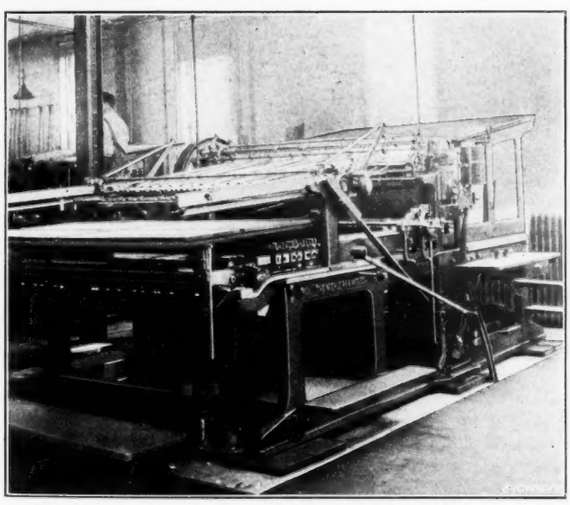


Fig. 10. Drum Controller installed for Controlling Motor-driven Printing Press

operating lever was considered essential to the successful operation of motors.

Modern Motor Starters

The present standard motor starter of the manually-operated type illustrated in Figs. 4 and 7 is built on the same principle as the first Blades structure. This device has, however, led to the development of innumerable kinds of motor controlling devices. The recognition of the value of the Blades patent by a Milwaukee electrical manufacturing company has been the means of the establishment of the largest plant devoted to the designing and building of motor controlling devices in the world.

Motor starters, starting rheostats, or "starting-boxes," as they are sometimes called, are used, as already stated, for starting an electric motor without excessive current inrush and bringing it gradually up to its normal speed. Some types of speed regulators are similar in appearance to starting rheostats, but the resistance employed is designed for carrying the full current constantly.

A starting rheostat used with the ordinary shunt or compound motor cuts out steps of resistance in succession as the lever is passed over the contacts. When the lever is held in contact with the magnet of the no-voltage release, no resistance is in circuit, but the current passes directly to the motor. Five to fifteen seconds is the usual period for starting a motor under ordinary load. Where the motor is driving a machine which requires very heavy starting torque, a starting rheostat having resistance designed for a longer starting period should be selected. A motor heavily loaded should be started slower, allowing the handle to rest for longer periods on successive contacts. This prevents large current inrushes and blowing of fuses, and takes from thirty seconds to one minute for the whole operation, depending upon the load.

Speed regulators for machine tool motors, fans, pumps, printing presses, controllers for hoists, cranes, elevators, etc., are made in types for every application, each providing special features, as required. In all cases the character of the drive and the motor data must be considered. For instance, a controller for a printing press must be differently proportioned from a controller for a lathe. With a printing press, the torque is about the same whether running with paper or without, and the vital requirement is to bring the motor up to speed smoothly and quickly.

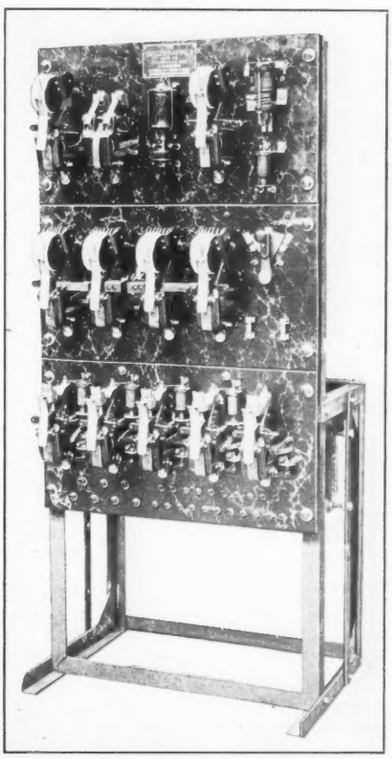


Fig. 11. Automatic, Magnetic Switch Type, Elevator Control Panel, for High-speed Electric Passenger Elevators, Multiple Solenoid Type

A motor speed regulator, such as used considerably for regulating ventilating fans, illustrated in Fig. 5, is practically a motor starter with resistance designed to be capable of being in circuit all the time the motor is in operation, instead of just five to ten seconds, as required in starters. The resistance must be ample to carry the full load motor current for long periods of time, so that the operating lever can be left on any contact segment. Fig. 8 shows a 10-foot fan driven by a 25 H. P. C. & C. direct current motor regulated by a Cutler-Hammer regulator mounted against the wall.

Speed regulation of shunt-wound and compound-wound motors may be effected by inserting resistance in the armature circuit of the motor, or by inserting resistance in the shunt-field circuit. The first method reduces the speed of the motor below its normal rated speed. The second method increases the speed of the motor above normal. Fig. 8A is an example of the latter type of control. The drill press shown is driven by a ½-horsepower Watson motor and a speed variation above normal is obtained by the combination starting and regulating rheostat within easy reach of the operator. By a combination of the two methods the speed of a motor may be both decreased below and increased above normal speed, thus affording a wide range of speed variation.

Speed regulation by armature resistance is open to two ob-

jections: first, the difficulty of maintaining constant speed under varying load conditions, and, second, the necessity of wasting energy to secure speed reduction. These objections are in part offset by the fact that speed reduction by armature resistance may be applied to any motor of standard design and requires nothing more than the simplest (and, therefore, least expensive) speed-regulating rheostat. In cases where the motor will be operated nearly always at full speed, and only occasionally at less than its normal speed, the difference in

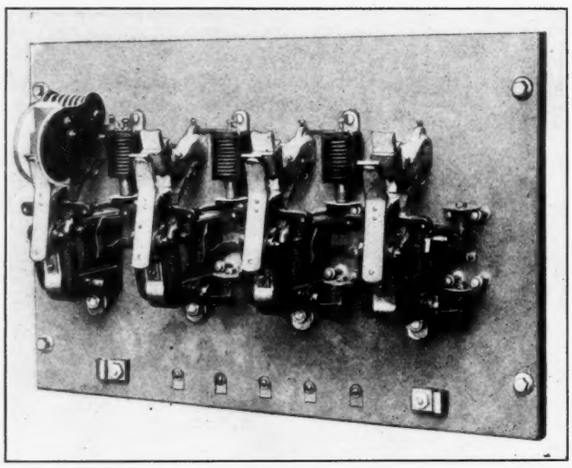


Fig. 12. Series Relay Multiple Solenoid Type Self-starter

first cost of the installation may justify the use of the armature resistance method of control. When the speed is changed frequently regulation by shunt-field resistance is preferred.

One of the most common errors is that of selecting a regulating rheostat of insufficient capacity. If the current required to operate the motor at full speed with no resistance in circuit is greater than the rated capacity of the rheostat, overheating of the resistance will result. An increase in temperature even

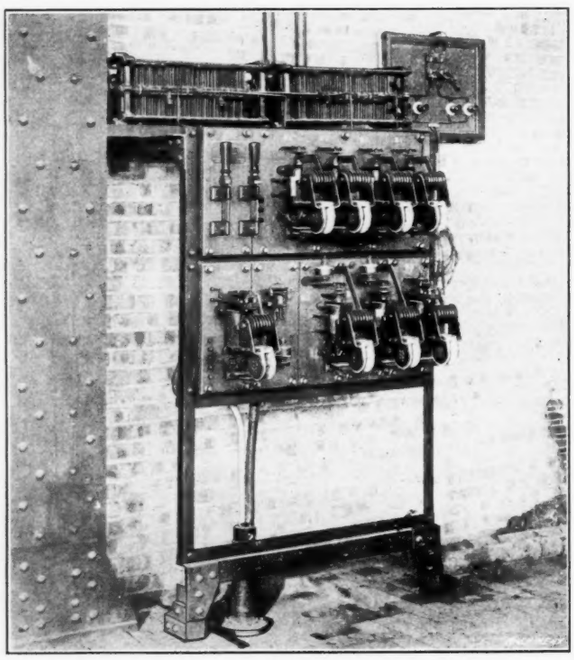


Fig. 13. Control Panel for Steel Mill Service. Magnetic Switches on the Panel are operated by Small Control Master Switch on Rolling Mill

to a point where the hand cannot be held on the enclosing case need cause no apprehension, but should the resistance become red-hot, the regulator is being worked beyond its capacity and the load on the motor should be reduced or a regulator of greater capacity substituted. If the current required to operate the motor at full speed with no resistance in circuit is less than the rated capacity of the regulator no over-heating will occur, but it will not be possible to secure the full fifty per cent speed reduction which the rheostat is designed to give with all resistance in circuit.

The power required by some kinds of motor-driven machines when running at slow speed is less in proportion to the reduction in speed than in other classes of machines, some of which take almost as much current when operating at one-half speed as at full speed. Typical examples of the two classes of machines referred to are furnished by a ventilating fan and a hydraulic pump, the current required to operate the fan becoming less and less as the speed of the fan is diminished, while in the case of the pump practically the same amount of current is required to operate it at half speed as at full speed. In other classes of service, such, for instance, as the speed regulation of ice cream freezers, several ventilating fans driven by one motor, line-shafting subject to variable loads, etc., the current requirements can only be determined by tests made at various speeds.

Drum type controllers, such as are used for machine tools, printing presses, cranes, etc., operated by a revolving handle at the top, are built on the same principle. They vary the speed by inserting resistance in the armature circuit and in the shunt-field circuit, and provide several reverse speeds or full reverse operation of the motor, as desired. A revolving drum carries segments, as shown in Fig. 9, so arranged as to

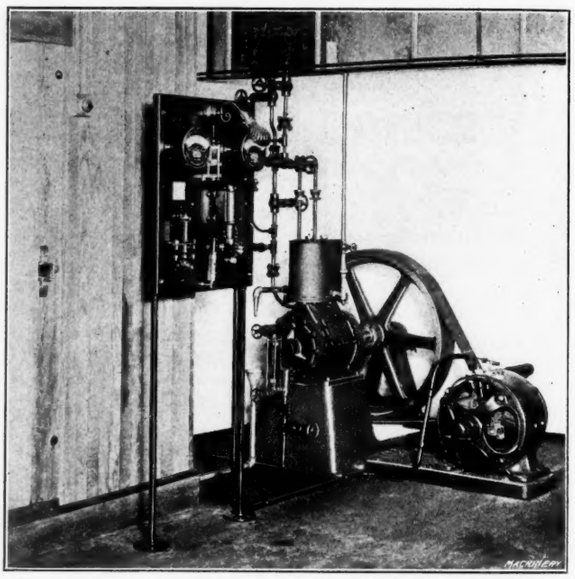


Fig. 14. Automatic or Remote-controlled Self-starters, used in Connection with Motors operating a Refrigeration System

make contact in a predetermined order with contact fingers. By means of accurate control the output of a machine can be increased, because for the various operations the most efficient speed can be employed. The method of mounting a drum type controller is illustrated in Fig. 10, which shows a flat bed printing press.

On the simple regulator, Fig. 5, it may be noted that contact to cut in or out the various steps of resistance is made by moving a handle or lever by hand. On automatic starters, regulators or controllers, the cutting out of the resistance is accomplished by magnetically operated switches. The principle is exactly the same. A simple automatic starter is illustrated in Fig. 6. The solenoid at the right side, when energized, closes the fingers at the top in succession and starts the motor with which it is used in the same manner as if the operation were by hand. In the "off" position all resistance is in circuit so that on starting there will be no current inrush. As each finger closes, a step of resistance is cut out. The last finger cuts out all the resistance.

An automatic control panel for varying the speed may consist of a number of magnetically operated switches, the closing and opening of which may be accomplished by pushing buttons connected in the switch magnetic circuit. Assuming that a motor is running at its normal speed and that it is desired to increase this, a control button connected so as to magnetize a switch, the closing of which would connect a resistance in the shunt field, is one means. The button may be located at any location

remote from the motor and control panel. Several typical control panels are illustrated in Figs. 11, 12 and 13.

For some motor applications it is now desirable to have the starting-box automatically operated, or capable of being started by pushing a button or closing a switch at some remote point. The "self-starter" or automatic starting device is one of the most interesting devices employed in connection with motors. Unless one has been able to keep in close touch with the development of electrical apparatus in recent years, one is likely to be astonished at the results accomplished by the various applications of the solenoid. This coil of wire which "sucks" in its iron plunger or core when energized by the passage of current through it, is used in what is called the dashpot-controlled self-starter and in the multiple solenoid current relay type.

In some plants automatic motor starters are installed solely for the purpose of preventing careless employes from starting up the motors too suddenly, but the value of the self-starter consists chiefly in the fact that when combined with suitable energizing devices, such as float switches, pressure regulators, limit switches, or even a push button switch, it dispenses altogether with the need of employing someone to start and stop the motor at the proper time, or else enables the one charged with this duty to control the motor from a distance.

In connection with motor-driven pumps and air compressors the self-starter finds one of its widest fields of usefulness. By means of a switch operated by a copper float in the tank, the circuit to the motor is automatically opened and closed through the self-starter whenever the water in the tank reaches a predetermined high or low level. The same device may be used in sump pits or, indeed, wherever there is sufficient change in water level to operate a float switch. In compression tank systems, and when used with air compressors, a pressure gage is substituted for the float switch, the circuit being made and broken as the needle, or indicator, moves back and forth between two fixed points.

A good example of the advantage of remote control is found in mining work where (in mines employing manually-operated starting-boxes) it is oftentimes necessary to send a man down the shaft to start a motor. In mines where self-starters are installed, every motor can be controlled by switches located in the power house, or at any other convenient point. In connection with electrically operated elevators, hoists, etc., the self-starter insures a smooth start and gradual acceleration to full speed, since by means of the dash-pot referred to the starting period is predetermined and is not affected by carelessness on the part of the operator.

In connection with refrigeration systems, automatic motor starters are frequently used for various purposes. The panel shown in Fig. 14 carries a main line knife switch, fuses, voltmeter and ammeter at the top, with an automatic starting rheostat and pilot switch for the motor driving the brine pump. By running control wires to several points in the building it is possible to start or stop the motor as desired from any of these locations. The starting is accomplished in the same manner each time, and the time of acceleration can be regulated to suit each particular requirement.

In short, practically every motor installation requires a controlling device. The choice of control is equally as important as the choice of a motor. All conditions should be considered in selecting the controlling device. Will the ordinary type of hand-operated starter be most economical or convenient, or would an automatic starter be better in the long run? Is speed regulation required? Is the device to be located where dust, lint, etc., are present in excessive quantities? Is the motor to be reversed? Is the motor of direct-current—series, shunt or compound type? Or of alternating current—single phase, or, squirrel cage or slip ring polyphase type? What duty will the motor be required to do? These are all questions concerning which information is required when considering the installation of the controlling apparatus.

* * *

In all places where bolts, studs, cap-screws, etc., are used, care should be taken to allow enough room for the use of a standard wrench.

CASEHARDENING TEMPERATURES

In an article in *Le Genie Civil*, Dr. L. Guillet gives some interesting information relating to casehardening methods and temperatures to be used in casehardening processes. In general, the regular carbon steels should be carbonized at a temperature of about 1560 degrees F. After carbonizing, the objects should be permitted to cool to about 1100 degrees F. or lower. They are then again heated and quenched from a temperature of about 1875 degrees F. for refining the core, after which they are again heated and quenched from a temperature of 1380 degrees F. for the final hardening. The quenching in both cases is done in water.

The carbon contents in ordinary carbon steel for casehardening should, in general, be from 0.10 to 0.15 per cent, and in no case should it exceed 0.20 per cent. In alloy steels the carbon contents may be as high as 0.30 per cent. The manganese contents should not exceed 0.40 per cent if a single quenching only is employed, but can be somewhat higher if two quenchings are used. Silicon increases the brittleness in all cases, and should not exceed 0.30 per cent. Tungsten and molybdenum also increase the brittleness of the core.

Nickel steels are very suitable for casehardening, but have, however, both advantages and disadvantages. Among the latter are that nickel seems to retard the process somewhat and the hardness of the case is somewhat lower than that obtainable in ordinary carbon steels. On the other hand, nickel tends to oppose the crystallization of the steel at high temperatures and to eliminate the consequent brittleness. Because of this, the first quenching for refining the core is not always necessary, although it noticeably increases the tenacity of the core. With a 2 per cent nickel steel the following temperatures are recommended: The first quenching should be from a temperature of 1830 degrees F. The second heating should be to 1380 degrees F., after which the quenching should take place after the objects have cooled off to about 1290 degrees F. A single quenching from 1290 degrees F. gives the greatest hardness in the case but not the greatest tenacity in the core. Quenching from 1380 degrees F. gives a somewhat higher tenacity but a slightly lower hardness in the case. A 6 per cent nickel steel should be quenched in the first instance from 1560 degrees F., and after reheating from 1245 degrees F. Since this high nickel percentage almost completely prevents the brittleness of the core, one quenching from about 1290 degrees F. is in most cases sufficient.

Steels with from 1 to 1.2 per cent chromium are sometimes used when an especially hard case is required. This element, however, aids the crystallization of the core and the double quenching is, therefore, absolutely necessary. Chrome-nickel steels with a low chromium content require about the same heat treatment as pure nickel steels.

The author does not recommend charred leather for a casehardening mixture, as he considers that it works too actively, but, instead, believes that a mixture of 60 parts wood charcoal and 40 parts of barium carbonate is the best to use. It is easy to obtain, is not expensive, and can be used over again for a number of times.

* * *

A combination of the moving picture machine and the phonograph has been recently demonstrated in London. The invention is of French origin and its development has been under way for a couple of years. Two electric motors are used, one for the moving picture machine and one for the phonograph. These are kept in synchronism by a special arrangement which makes it possible to instantly remedy any defects in the relative speeds of the two instruments. The combination machine is called "chronophone." At the demonstration, prominent actors could be seen reciting monologues. The sounds and the movements on the screen were in perfect harmony. One remarkable picture was that of a lion tamer in the cage of the animals. The mixture of sounds—those of the man speaking, the crack of the whip, the thud of an iron bar falling on the floor of the cage, and the growls of the lions—harmonized perfectly with the pictures. As these are also shown in natural colors, the illusion seems perfect.

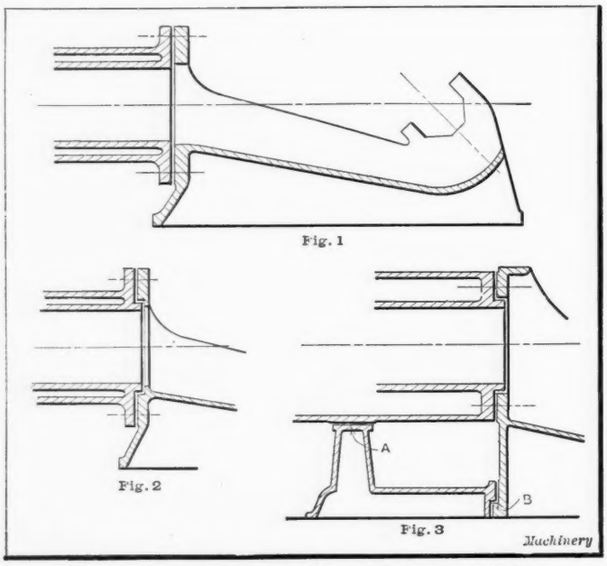
DESIRABLE IMPROVEMENTS IN AMERICAN GAS ENGINE DESIGN*

By C. F. HIRSHFELD†

The designer of gas engines has a double problem to solve. He must not only develop an apparatus which will function properly through a long life, but he must also, in general, design it in such a way that it can be built at a cost which will make it possible to meet competition. In criticizing commercial designs one must, therefore, bear in mind that manufacturing costs limit the refinement of design; but manufacturing costs do not excuse poor designs which a resourceful designer could improve without making the machine more expensive; nor do they excuse designs which make it difficult or impossible for an engine to function properly through a reasonably long life. Such design may give a manufacturer a temporary advantage, but it can never result in giving him a permanent share of the engine business. In the following paragraphs, some of the faulty constructions which are more or less common in small and medium sizes, will be pointed out, and better methods suggested.

One of the most glaring faults still found in many American gas engines of the horizontal type is the unsupported, overhung cylinder shown in Fig. 1. In very small sizes this construction would be justifiable if it were not more expensive than other and better designs which can be used for small engines; in medium and large sizes it is well-nigh inexcusable. The studs or bolts which hold the cylinder to the frame, and which often pass through unfinished, cored holes, cannot be depended on to keep the cylinder in proper alignment. These fastenings are, moreover, not well adapted for taking care of the normal pressure of the piston and of the weight of the cylinder and piston. In the case of large engines constructed in this way it is sometimes possible to notice a measurable deflection of the cylinder during the expansion stroke.

If this general type of design is deemed necessary because of the present investment in drawings, patterns, etc., it should at least be modified as shown in Fig. 2, so that a generous

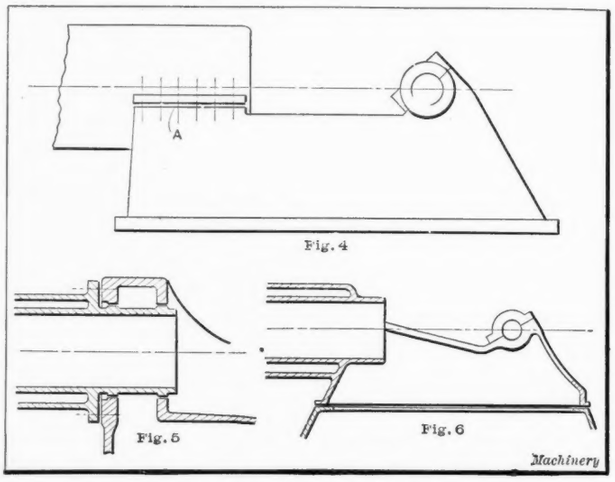


Figs. 1 to 3. Methods of Attaching and Supporting Cylinders

counterbore serves to locate the cylinder and to prevent motion of the crank-end with respect to the frame. The next simplest improvement is to slightly modify the patterns, using a support such as that shown in Fig. 3. This should be cast with, or bolted to, the frame, and should be so arranged that the cylinder can slide back and forth upon it at the point of support *A*. To secure accurate alignment when this auxiliary support is bolted to the frame, some kind of shoulder bearing, such as that shown at *B*, should be provided. Another solution, but a more expensive one, is to allow the cylinder barrel to extend into the frame for a considerable distance, as shown in Fig. 5.

One of the most satisfactory designs, so far as locating and supporting the cylinder is concerned, is that shown in Fig. 4. By making the bench at *A* short in the smaller sizes, the necessary support can be given the cylinder without necessitating the use of an excessive amount of metal in the frame. As the size of engine increases, this bench can be made relatively longer, thus giving the more perfect support required in higher powers. This design is particularly desirable from the manufacturing point of view, because the machine work is simple in character, and because, if properly designed, one frame can be used with several sizes of cylinders.

For very small single-cylinder engines some makers have developed designs similiar to those in Figs. 6 and 7, in which the working bore, jacket and frame are all cast in one. For small sizes this is a satisfactory solution; for larger engines



Figs. 4 to 6. Methods of Attaching Cylinders to the Frames

it should be so modified as to permit of the use of a separate cylinder liner, as shown in Fig. 8.

In tandem engines the front cylinder should be supported in much the same way as in the single-cylinder type. The rear cylinder should be located with respect to the front cylinder by counterbored flanges which are finished when the cylinders are bored. These flanges should not, however, be called upon to resist bending moments caused by the weight of the cylinder, the thrust of valve mechanisms, etc. This bending moment should be taken care of by a simple support. A modification of the support shown in Fig. 3 is adapted to this case. The use of a support entirely separated from the main frame, a common practice in tandem constructions, is not to be recommended. The accuracy of its location depends entirely upon the care exercised by the erector, and is beyond the control of the manufacturer.

There seems to be a difference of opinion as to the necessity of a crosshead in single-acting tandems. From the viewpoint of rational design, there can be no question: a crosshead should be used. A piston cannot perform the functions of a crosshead without impairing the perfection of its action as a piston. From the viewpoint of the designer, however, the case is different. However desirable a crosshead may be, financial considerations may not be neglected. Although the crosshead itself is not necessarily a very expensive piece, it involves the use of a piston-rod and guides; but many manufacturers increase the cost of crosshead constructions very considerably by using an unnecessarily complicated crosshead. With proper slipper surfaces, no wedge adjustment is required on this member. A simple construction so arranged that the lower slipper can be moved down by the insertion of shims, if it should become necessary, is all that is required. As a result of the balance between cost and desirability, trunk-piston designs are generally used in smaller sizes, and crossheads in larger engines. The split might well be made at about 100 horsepower per crank. The reboring and ultimate replacement of 50 horsepower cylinders will, in general, about

* For additional information on this and kindred subjects, see MACHINERY, February, 1912, engineering edition, "Points in the Design of Two-stroke Cycle Engines," and the articles there referred to.

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balance the interest on the additional investment involved in a crosshead engine.

The cylinders of single-acting engines of American design are often open to considerable criticism. One of the most common faults is the use of a working barrel and jacket of too nearly the same diameter, giving inadequate jacket space. Faults that generally accompany this are the entire omission of openings through which this space can be cleaned, or the use of openings so small and so distributed that they are of little practical use. Builders of what may be called "stock" engines can seldom be sure that their engines will not be used in places where the only available water is muddy or carries large quantities of mineral matter in solution. If designers would regard the jacket as a water heater as well as a cylinder cooler, fewer designs of the kind mentioned would appear. Openings into the jacket space should be of such size and number that all parts of the interior can be easily reached, so that mud and scale can be cleaned out.

It is not good practice to make provision for cleaning by combining the jackets of the cylinder and of a separate cylinder head, that is, making them continous, as shown in Fig. 9. Experience has shown that joints of this kind are very difficult to pack. Leakage of water into the cylinder is apt to occur, causing irregular operation, or, if this can be prevented, water is apt to leak to the outside of the engine. If such cored passages are deemed necessary by the designer for the support of cores or for simplicity of construction, the head should be made to fit into the end of the cylinder with a metal-to-metal contact at some point in the counterbore, in order that the gas pressure acting on the inner edge of the gasket may be reduced to a minimum. It is, however, far better to cast the abutting faces solid and to carry the water around from jacket to jacket by means of a U-shaped connection. Even in this case many troubles will be eliminated if the counterbored construction is adopted. This method of protecting the gasket against blowout is well worth while.

Vertical engines have many head joints which are difficult to properly care for in operation. Whenever valves are placed

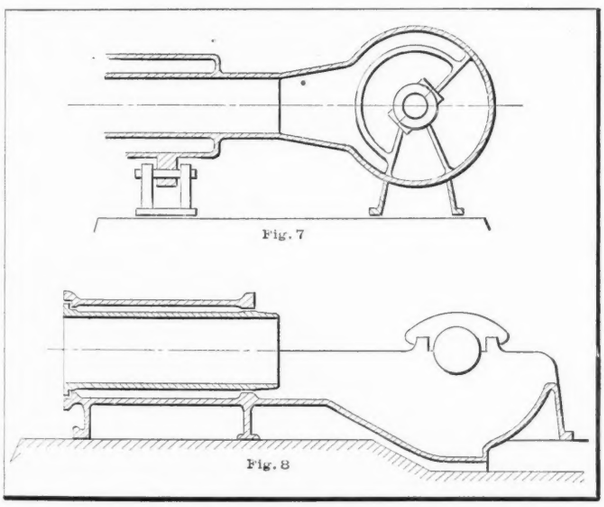


Fig. 7

Fig. 8

Fig. 7. Arrangement for Small Single-cylinder Engines. Fig. 8. Frame for Heavy Engine

in side chambers or pockets in high-compression engines of this type, it becomes difficult to design proper covers for the cylinder and valve chambers. The ideal arrangement would be the use of circular covers for each part, with each cover fitting into a counterbore, as shown in Fig. 10. When high compression and large valve diameter are desired, it becomes necessary to decrease the distance between the center line of the cylinder and the center lines of the valves. This generally makes it impossible to leave enough metal at point *A* to make it feasible to use separate covers, and there is a tendency to split along the line *BC*, move the valve toward the cylinder, and use non-circular covers. Not only does this construction require non-circular gaskets and prevent the use of counterbores, but it also often makes it impossible to finish the abutting surfaces with circular cuts which do not run off the edge of the casting. The satisfactory packing of a joint of this kind is often a matter of great difficulty. If, in addition to the disadvantages already enumerated, the gasket is called upon to take care of a continuous jacket, such as that previously mentioned, it will require both skillful manufacture and attendance, to keep the engine in successful operation.

These considerations and others to follow form strong arguments in favor of the location of valves in the head in high-compression vertical engines, if not in all engines with a vertical center line. Other advantages are simple cylinder castings, better shape of combustion space, and general accessibility of valve operating mechanism. The advantages accruing from valves in the head are particularly noticeable in

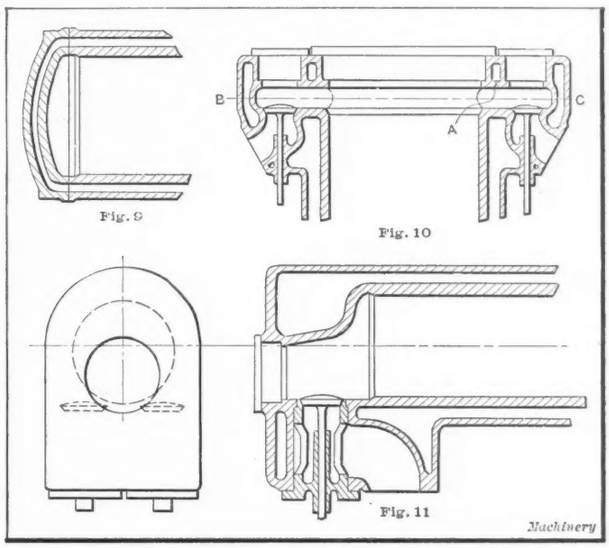


Fig. 9

Fig. 10

Fig. 11

Figs. 9 to 11. Cylinder and Valve Arrangements

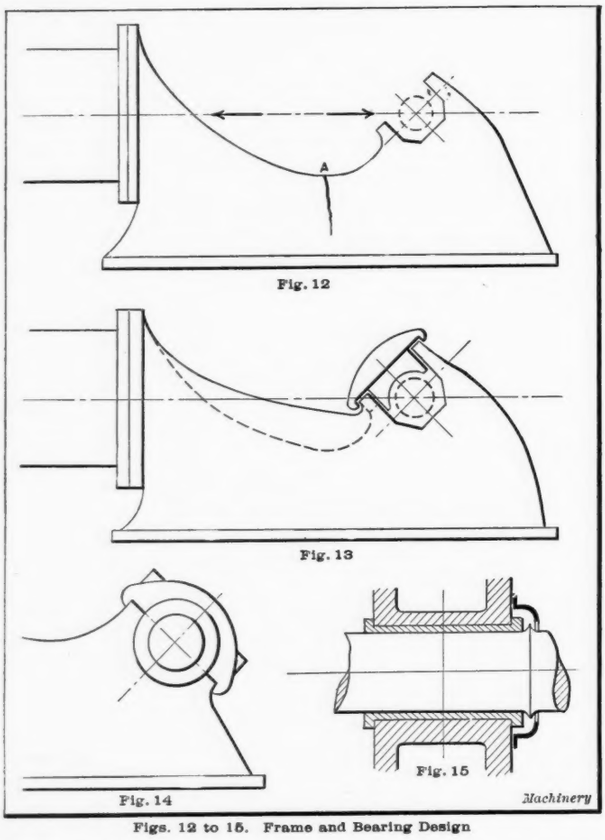
Diesel engines, which are almost universally constructed in this way.

While speaking of valves and valve gear, it will not be amiss to consider some of the designs used in horizontal constructions. There are still a large number of these engines constructed with horizontal valves, that is, valves with their longitudinal axis horizontal. It needs no theoretical discussion to prove that such an arrangement is incorrect; the engines themselves prove that. Such valves are bound to wear their guides and seats out of round at a comparatively rapid rate. It is no more expensive to use vertical valves, and it is no more difficult to devise the operating mechanism for such valves.

In small types of horizontal engines with vertical valves, these members are located at the top and bottom in the cylinder or head, in chambers at the side or sides, and side by side in the bottom of the combustion space. The last-named location is generally preferable on the grounds of cheap construction and simple operating mechanism. An arrangement of this kind is shown in Fig. 11. This design is open to the objection that the volumetric efficiency of the cylinder is decreased by the heating of the incoming charge, which must pass in close proximity to the hot exhaust valve. The thermal efficiency is also apt to be slightly decreased by the loss of unburned mixture, if any considerable overlap of valve events is permitted. For small engines, however, these considerations are insignificant in comparison with the advantages to be gained by this construction.

Valves in pockets cast or bolted to the walls of the cylinder are open to criticism because of the poor shape of the combustion space, the complication of the cylinder end and its jackets, and the more complicated mechanism generally found necessary; but these pockets have the advantage of making it possible to remove the valves through plugged openings, so that valve cages are not necessary. In this sense the construction is cheaper than that just recommended; but on the other hand the advantages of valve cages are so great and the difference in cost so small, that cost can hardly be urged as a justification for valves in pockets.

Such seemingly simple things as frames are often incorrectly designed, particularly in the smaller sizes of horizontal engines. It is evident that the end of the frame to which the cylinder is fastened and the end which supports the bearings tend to separate during each combustion and expansion. To prevent this they are tied together by the metal in the frame. The most effective way to tie two pieces together against the action of separating forces is to put the tie member in such a position that its gravity axis coincides with the line of action of these forces. If this is not done there must be a bending moment on the binding member. A common type of frame is shown in Fig. 12. The two arrows in the center line show the line of action and the directions of the separating forces. It is evident that the upper surface of the frame will tend to separate at some such point as *A*. The result will be a crack extending downward. The trouble can be remedied by raising the upper lines of the frame as shown in Fig. 13, in which the dotted lines indicate the construction of Fig. 12. This results in bringing the gravity axis of the



Figs. 12 to 15. Frame and Bearing Design

frame section nearer to the center line of the engine and thus reduces the bending moment.

Many designers deem it desirable to use a bearing split at an angle as shown in Fig. 13, in order to take up the maximum thrust with the strong, cantilever-like piece which backs up the bearing. With this design it is difficult, although not impossible, to carry the top line of the frame as high as desirable, and as a result many of the engines now built in this way have abnormally strong bearings in proportion to the strength of their frames. In all but the smaller sizes it is better to use a design such as that shown in Fig. 8; it gives more nearly the same strength in different parts of the frame. Some makers are still using the type of bearing shown in Fig. 14. For this type there can be no justification. The maximum thrust must be taken largely by the cap and transmitted to the frame through the studs which hold that cap in place.

Another fault in some frames as now built in this country is to be found in the footings or surfaces on the lower side of the frame which are to rest on the foundation. In large engines, which may reasonably be expected to receive proper care in erection, it is good practice, when necessary, to use transverse footings within the walls of the frame, as shown in Fig. 8. In small engines there is no need for such supporting surfaces. The support furnished by the feet on the walls at side and end, is amply sufficient, and bearing surfaces inside of the walls may do more harm than good in the hands of a careless erector.

The downwardly projecting crank-case is a weak point in many engines of the smaller type. In large engines it is often necessary, if the shaft is to be at a convenient height above the floor, but this argument does not hold for the smaller sizes. Where small engines are designed as stock types, it is far better to protect the bulge of the crank-case with slightly deeper frame walls.

Many designers have not yet realized the desirability of an oil groove or channel on the outside of the frame at the bottom. Such a groove adds little to the molding cost, but adds materially to the ease with which the engine and foundation can be kept clean and free from oil. The channel should be properly sloped to insure drainage, and a drain provided at the lowest point, preferably at the front of the engine. It should also be noted that oil channels which are broken up into several undrained or imperfectly drained parts by bosses for foundation bolts are little better than no channels at all.

In the same class with these oil channels are oil guards over the crank-case in horizontal engines, and oil drains at the lowest point of the crank-case in all types. Unfortunately these are often ignored through ignorance, or as a foolish means of cutting down costs. Many of the larger engines in which oil channels, crank-case guards and oil drains are provided as a matter of course, are still faulty in that no provision is made for taking care of the oil which works out of the bearings and along the shaft. Splash rings and guards, such as those shown in Fig. 15, are not very expensive, and they materially assist in maintaining cleanliness.

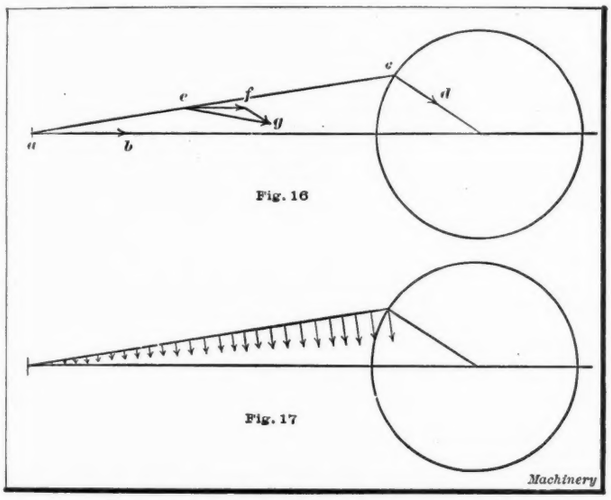
A very weak point, characteristic of American design, is the exposed or partly exposed gear. When possible, cam shaft and similar gearing should run in an oil bath and be entirely enclosed. There are, however, many types in which such an arrangement would be very expensive, but this should not be used as an excuse for leaving these gears poorly protected or not protected at all. Danger of injuring the attendant is not the only thing to guard against; it is also necessary to prevent accidental damage to the gears. There are many engines now on the market in which the gears are so protected that it would be practically impossible for an attendant to get caught in them, but which have the guards arranged in such a way that tools can easily be dropped onto or between the meshing teeth. Several engines which were temporarily disabled in just this way within a few weeks after installation have recently come to the attention of the writer.

Another weak point in American design, which fortunately is now being rapidly eliminated, is the use of a malleable iron connecting-rod. It is generally conceded that the proper material for connecting-rods is steel, forged or cast in the smaller sizes, and forged in the larger. It is true that malleable rods are used only on single-acting engines, in which the maximum load puts the rod in compression, but these rods are too weak and are liable to fracture. The compression loading is only part of the story. Every connecting-rod, in operation, is also loaded like a beam, and iron is notably not the proper material for use in a beam. This beam loading is illustrated in Figs. 16 and 17. The acceleration at the wrist-pin end of the rod is shown in Fig. 16 by the arrow *ab*, and the normal acceleration at the crankpin end by *cd*. Any point between these two is subject to an acceleration which may be regarded as made up of two components, one parallel to and smaller than *ab*, the other parallel to and smaller than *cd*. These components and their resultant are shown for one point in the length of the rod by *ef*, *fg* and *eg*. If the normal accelerations of all the points be found, they will be about as represented in Fig. 17. Since there can be no acceleration without an accelerating force, there must be forces acting along the length of the rod in the same general way as do the accelerations in the illustration. It will be observed that these forces load the rod as a beam. The existence of these forces also shows the folly of using an H-section as is done by some makers. An I-section is rigid in the plane of rotation and

is well able to care for the beam loading; an H-section is not sufficiently rigid in this direction.

While on the subject of connecting-rods, it would be well to speak of the methods provided for taking up wear at the two ends. In normal operation the wear at the crankpin end will be far in excess of that at the wrist-pin. The design of adjustments which will leave the distance between the pins the same is, therefore, practically impossible. The designer must decide whether the rod is to grow shorter with age, giving decreasing compression and efficiency, or whether it is to grow longer with the opposite results, and with the possibility of causing preignitions because of high pressures. The former is generally preferable as being safer, although the kind of fuel, the compression pressure for which the engine is designed, the kind of attendance which may reasonably be assumed, and a number of other considerations should also be given due weight in arriving at a conclusion. One case has come to the writer's attention which is interesting as illustrating what extreme conditions may be attained in practice. Wear was taken up in such a way as to lengthen the rod to such an extent that the first piston ring was driven into the counterbore of the cylinder and effectually locked the piston. This is, of course, a most exceptional case, but serves to show what is possible with some engines in some hands.

It has become recognized as desirable to provide means for adjusting the time of ignition while the engine is in



Figs. 16 and 17. Forces acting on Connecting-rod

operation. There are still many engines built in which such adjustment cannot be made. It may surprise some, but it is nevertheless a fact, that several large engines which are commonly recognized as "standard designs" have no such provision. The convenience of being able to adjust the time of ignition during operation can hardly be questioned, and it is absolutely necessary with producer gas engines.

Another weak point in many ignition systems is the lack of proper provision for taking up wear. The parts are of necessity rather small, and rub across one another millions of times per year. Adequate lubrication is difficult, and wear is certain. Such systems should always be so arranged that the effect of wear upon the timing can be compensated for in a simple manner, and that considerable wear can occur before it is necessary to replace parts of the apparatus. It is rather remarkable that more manufacturers have not deemed it advisable to adopt the high-tension system which has proved its worth under the severe operating conditions pertaining in automobile practice. This type combined with careful construction can be relied upon to give most satisfactory results.

* * *

The methods of Russian high finance are startling, if we can accept the report current in regard to the use of certain die-casting machines recently bought. It is alleged that ten die-casting machines were lately bought by the Russian Government from a New England concern, for making certain Russian coins. The price was the mere bagatelle of $40,000 each.

THE INFLUENCE OF HEAT ON HARDENED TOOL STEELS*

By testing various samples of carbon steel in the tool steel testing machine designed by the author, it was found that carbon tool steels have a very low durability at a low cutting speed; that there is an increase of durability as the cutting speed increases; and that a maximum durability of cutting speed is obtained at about 50 to 80 feet per minute. There is then a decline of durability to a very low value if the cutting speed is further increased. These general characteristics are common to all tool steels that have been tested, whether of the carbon or high-speed steel type (tungsten or tungsten-vanadium varieties). All of these give, when the durability is recorded in diagrammatic form, a single- or double-peaked curve, according to the heat-treatment they have received. All show a low durability at low cutting speed, this characteristic being especially marked in the case of some high-speed steels, which latter often retain their durability at very high speeds.

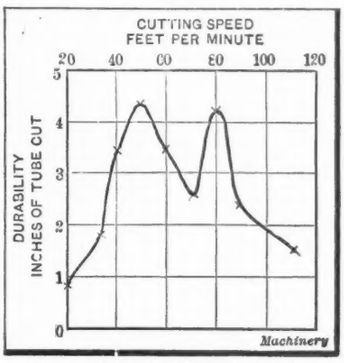


Fig. 1. Example of Double-peaked Durability Curve

The author, at a previous occasion, has pointed out that the observed changes in the durability of cutting tools are mainly caused by the changes in the temperature of the cutting edge, due to the heat generated at different cutting speeds. This heat theory has been confirmed by experiments showing that changes of durability corresponding to those which occur under varying cutting speeds can be produced by varying the temperature of the tool in other ways, while the cutting speed remains constant—for instance, by varying the temperature of the water with which the tool is flooded, or by varying the depth of the cut (a heavy cut generating more heat than a light one), or by dispensing entirely with the cooling water.

The various problems that were dealt with in the experiments were as follows:

1.—It has been found by experiments on the tool steel testing machine that all tool steels, without exception, have a very low durability, and are very quickly blunted when cutting under water at low speeds and fine cuts, that is, under conditions which preclude any considerable heating of the cutting edge; and it has been found that any alteration in the cutting conditions which tends to increase the temperature of the cutting edge results in an increased durability of the tool. What, if any, are then the correlative changes in the physical properties (strength, hardness, toughness, etc.) of hardened steel which occur when it is raised from a low to a higher temperature?

2.—All varieties of tool steel have been found to be capable when suitably hardened, of producing double-peaked speed-durability curves (see Fig. 1), the characteristics of such steels being that at a certain speed they are less durable than at either a higher or lower speed. Is it possible to correlate this low durability at a certain speed with a particular physical condition at a certain temperature?

3.—All tool steels are found to lose their durability when the cutting speed is raised above a certain limit. Is there any corresponding change in their physical properties when they are heated above a certain temperature?

4.—Assuming that each cutting speed corresponds to a definite temperature of the cutting edge (the weight of cut and all other conditions remaining constant), what are the actual temperatures of the cutting edge corresponding to the various cutting speeds, and corresponding to the various changes in the durability and physical properties of the steel?

Before dealing with these problems, it is necessary briefly to consider the nature of the actions tending to wear or blunt a cutting tool, and the correlative physical properties constituting durability, which the tool must possess in order to withstand these actions. The principal action to which a tool is subjected in cutting is one of friction under heavy pressure. This tends to rub away the surface of the steel, by causing

* Abstract of a paper read by Mr. Edward G. Herbert before the Iron and Steel Institute, Great Britain, at the May, 1912, meeting.

the particles of steel to slide over one another. To resist blunting by this action a tool must possess hardness. But the stress on the tool point is not constant: as the chip is detached it breaks up into a series of short segments (more or less completely separated), and this process subjects the tool to a succession of changes of pressure, amounting almost to blows, and tending to chip off portions of the cutting edge. To withstand this action the tool must possess toughness.

If we make a tool of glass and another of copper, and use them to turn a cylinder of soft material such as lead in the lathe, we shall find that both are very soon blunted, but from totally different causes. The glass tool, though extremely hard, is brittle, and is blunted by the chipping away of minute particles of the cutting edge. The copper tool, though very tough, is soft, and is blunted by the rubbing away of the cutting edge. If now we imagine that by some subtle alchemy we can gradually change the tool of glass into one of copper, it will probably pass through some intermediate stages where it will retain some of the hardness of glass without all its brittleness, and will have attained some of the toughness of copper without all its softness. The tool in this intermediate state will probably keep its sharp cutting edge much better than either the glass or the copper tool.

In order then to measure, throughout a range of temperatures, those physical properties of steel which constitute its durability, it is necessary to test it at each temperature for hardness and for toughness. Experiments with suitable apparatus were, therefore, carried out for measuring the hardness and toughness at various temperatures, taking into consideration such factors as different methods of grinding the tools, etc. The experiments made it possible to answer the questions propounded above, as follows:

1.—The low durability of all tool steels, cutting under water at low speeds and light cuts, seems to be completely explained by the low values of hardness and toughness which always occur at cutting temperatures of 50 to 100 degrees C. (122 to 212 degrees F.). The breaking tests have shown in every case the product, hardness times toughness, increases in value as the temperature is raised above 100 degrees C. The cutting tests have shown in every case that the durability increases when the cutting speed is raised above 20 feet per minute. These cutting tests have also shown that the durability always increases when a tool working at 20 feet per minute is allowed to cut dry instead of with water, or with hot water instead of cold. It is impossible to doubt that these are different manifestations of the same physical change in the steel.

A clear recognition of this phenomenon is of great practical importance. A great deal of the metal cutting in every machine shop consists in taking fine finishing cuts, often with water on the tool. If such cuts are taken at a slow speed, the temperature of the cutting edge may not rise above 100 degrees C., in which case the tool will be quickly blunted. Its durability can be increased by increasing the speed or by cutting dry. Many cases are known to have occurred in ordinary workshop practice, where an increase in cutting speed has actually resulted in increased durability of the tool. Low durability at low cutting temperatures (on, for example, finishing cuts) is a familiar characteristic of high-speed steels, and is most marked in tools which have been suitably hardened for very high temperature work. High-speed steel can be so hardened as to retain its durability at fairly low temperatures, and there are now on the market tungsten steels specially adapted for low temperature work, such as finishing very heavy forgings; but every description of steel known to the author loses its durability if the cutting temperature is low enough. It should be noted that a low cutting temperature can only occur when there is a combination of low speed with light cut. A heavy or moderate cut raises the temperature of the cutting edge above 100 degrees C., even at very slow speeds.

2.—The phenomenon of the double-peaked curve is not completely elucidated, though the evidence goes some way to explain it. The variations of hardness and toughness with temperature are of a complicated character, and the cleft between the two peaks of a durability curve appears to be caused by the conjunction of depressions in the hardness and toughness curves at a particular temperature. The relative heights of the two peaks are found to vary with the conditions of cutting, and this variation may be due to a change in the relative importance of the hardness and toughness factors, according to the quality of the material cut, or the shape of the tool.

3.—The decline in durability which takes place when a certain limiting speed is exceeded, is evidently caused by an actual softening of the cutting edge by the heat generated in cutting. This softening, which is extremely local, takes place even when the tool and the work are practically immersed in running water. The speeds and temperatures at which the softening occurs depend largely on the particular hardening process which has been applied to the tool, and are generally highest in high-speed steel.

4.—It is not yet possible to establish an exact scale of cutting temperatures corresponding to the scale of cutting speeds, but a comparison of the temperature-durability tests with the speed-durability tests enables us to make an approximation, as in Fig. 2.

To establish the relation between the speeds of cutting with and without water, a comparison was made between the various results obtained in the tests, from which it appears that the effect of using water is approximately to double the cut-

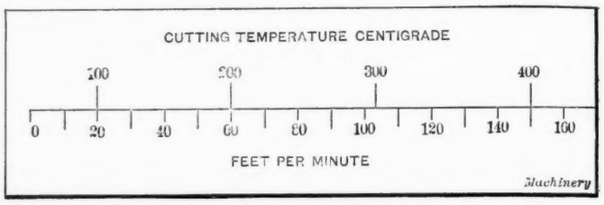


Fig. 2. Approximate Scale of Cutting Temperatures and Cutting Speeds, when Testing in Tool Steel Testing Machine

ting speed; in other words, the edge of a tool flooded with water attains about the same temperature as the edge of a tool cutting dry at half the speed. This must not be taken as a general statement applicable to all cutting operations. The dry cutting temperature depends largely on the volume of metal operated upon. The tube used in the tool steel testing machine is small in diameter and light in section; it becomes considerably heated under a dry cut. In machining a large forging, the body of metal absorbs a great deal of heat, with only a slight rise in temperature, and the use of water has less effect on the cutting speed.

Considerable interest attaches to a comparison of the durabilities of carbon and high-speed steels. It appears that the high-speed steel has two distinct features of superiority. The speeds at which it attains its maximum durability are not very different from those at which carbon steel is most durable, but the high-speed steel is several times as durable at these speeds. Quite distinct from its superior durability at moderate cutting temperatures is the property possessed by high-speed steel of retaining some durability at temperatures high enough to soften carbon steel, but its actual durability under such conditions is much less than under conditions which do not unduly heat it. In other words, its abrasive quality appears to be more important than its heat-resisting quality.

* * *

ERRORS IN JUNE DATA SHEET

We have been advised by the Society of Automobile Engineers that a few errors appear in the specifications for heat-treatment of carbon and nickel alloy steels reported by its Iron and Steel Division, January, 1912. The data of this report which was condensed into the June Data Sheet also contains the errors which are as follows: In Table I, reduction in area for annealed 0.10 carbon steel should be 55 to 65 per cent instead of 60 per cent; elongation of 0.50 heat-treated carbon steel should be 5 to 20 per cent instead of 0 to 20 per cent. In Table III, elongation of 0.40 carbon high nickel-chromium steel should be 2 to 15 per cent instead of 0 to 15 per cent; same for 0.45 carbon high nickel-chromium steel; and 150,000 to 225,000 pounds elastic limit for heat-treated 0.50 carbon chromium-vanadium steel instead of 150,000 to 200,000 pounds.

* * *

A few years ago engineers considered that 8, 10 or 12 square feet of heat transmitting surface per boiler horsepower was good practice, but improvements in the circulation system of steam boilers have made possible great increases in efficiency and now the ratios have been cut down to 4, 5 or 6 square feet per boiler horsepower.

THE RIVETT INTERNAL GRINDING MACHINE IN THE AUTOMOBILE FACTORY*

By CHESTER L. LUCAS†

The manufacture of automobiles has done much to develop general machine shop practice, and the necessity for mechanisms requiring hardened and ground parts has created a demand for the best that can be produced in grinding machinery. In internal grinding of the smaller variety, considerable trouble was met with at first in securing a suitable quill-spindle that would maintain its accurate adjustment and still run at the high speeds required in the grinding of holes of small diameter. A second difficulty was encountered in grinding holes perfectly straight, without tapering or "bell-mouthing." Grinding machine builders soon recognized the fact that before internal grinding could become of great value as an accurate machining operation, these two primary troubles must be overcome.

One of the first persons to recognize the possibilities of internal grinding, as well as the limitations of the machines in

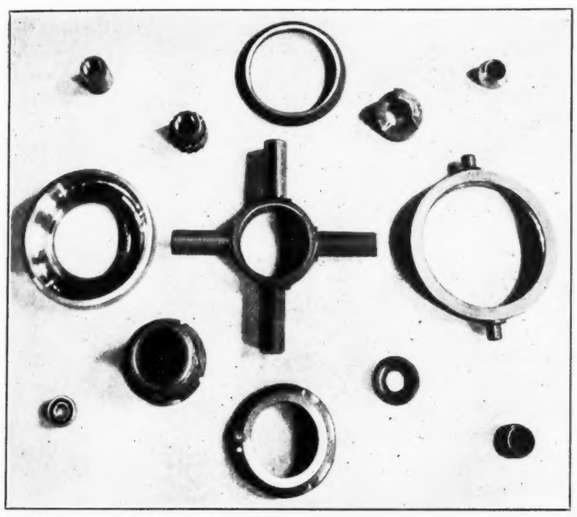


Fig. 1. Some of the Automobile Parts ground on Rivett Grinding Machine at the Stevens-Duryea Co.'s Factory

use, was Mr. Edward Rivett of the Rivett Lathe Mfg. Co., Boston, Mass., who, in 1900, took out a patent on an improved form of grinding machine quill-spindle. This spindle was designed to run at the high speed required for internal grinding and was designed particularly to overcome the end shake of the spindle, as well as to insure the proper fit of the spindle in the bearings. Essentially, this spindle consists of a centrally located shaft upon which is a fixed collar. Against this collar, sleeves are fitted which may be adjusted laterally

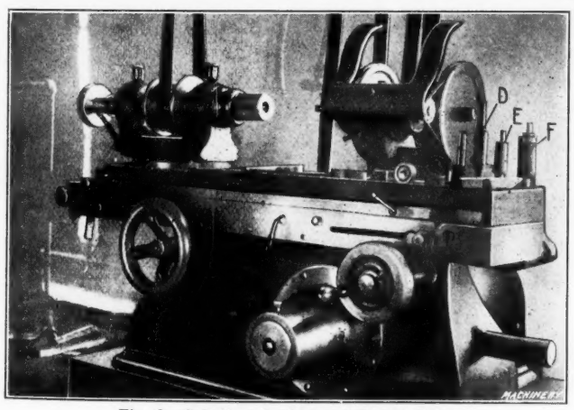


Fig. 2. Grinding the Bores of Tappet Rolls

against suitable washers which bear against the sides of the collar, thus effectively taking up the end thrust. The spindle itself runs in two split bushings, one on each side of the collar. These bushings are adjusted to the spindle by means of two sets of tapered wedges fitted in holders placed about these bushings. With this spindle, which is driven by belts passing from pulleys at both ends of the quill-spindle, speeds as high as 100,000 revolutions per minute can be obtained, although the usual speed employed is far less.

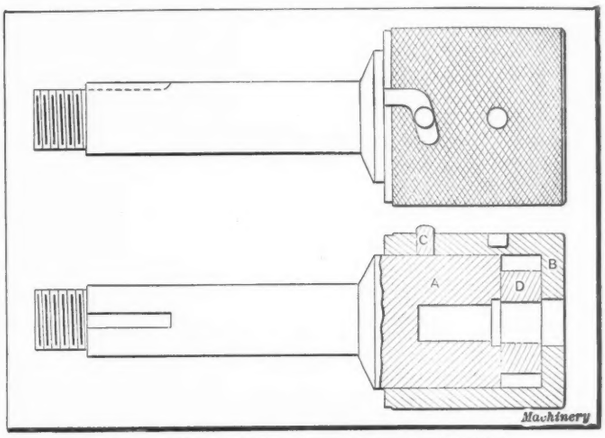


Fig. 3. Method of holding Tappet Rolls for Grinding

This style of spindle was used successfully for several years, until in 1907 Mr. Rivett brought out the new high-speed ball bearing spindle, which has superseded the former one. This spindle has specially designed ball races, made of a high grade of steel, and ground and lapped on Rivett ball grinding machines, which makes it a most rigid and durable type. The adjustment of these spindles is very simple, as there is but one screw, which governs both the end and side shake simultaneously.

In meeting the second obstacle in the path of successful internal grinding, that is eliminating the tendency toward grinding tapering or bell-mouthing, an important problem was solved. It was generally conceded that this tendency toward

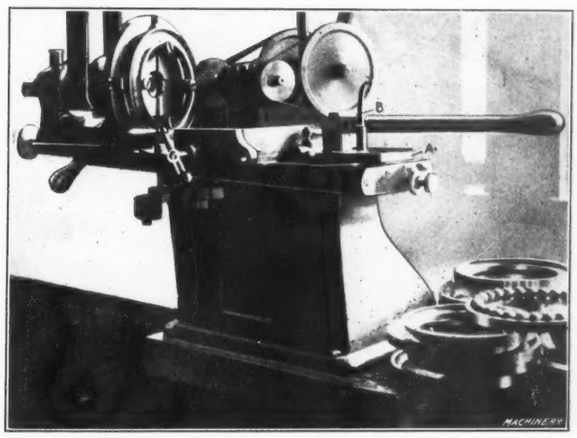


Fig. 4. Grinding Ball-races. Photograph taken at the Becker Milling Machine Co.'s Shops, Hyde Park, Mass.

bell-mouthing in internal grinding was due to the fact that in reciprocating the table of the grinding machine in the ordinary way, the table moved with varying speed throughout the whole distance of travel. Thus, at the extreme ends of the stroke the table was moving more slowly than at the central portion; consequently more stock was removed from the ends of the hole than from the central portion, as the wheel was in contact with the work longer at these sections. In 1904, Mr. Rivett patented a mechanism for changing rotary into reciprocating motion, and applied the principle to his grinding machines. In brief, this mechanism consists of a lever mounted on the base of the grinding machine and fulcrumed near its central point. The upper end of this lever is connected to the table by means of a link, and the lower end carries a roller whose position is adjustable in relation to the fulcrum. This roll serves as a means of contact with a conical heart-shaped cam.

The object of this special table traversing motion is to pro-

* For additional information on this and kindred subjects, see the following articles previously published in MACHINERY: "Holding Work for Grinding," March, 1912; and "Internal Grinding Practice in the Hardinge Bros. Shop," May, 1912.

† Associate Editor of MACHINERY.

vide a slight retardation at the middle of the stroke. The gradually accelerated traverse of the table towards the ends of the stroke gives less cutting time on the ends than at the center, thereby producing a hole which is about one ten-thousandth of an inch larger in the center than at the ends. In order to provide for the traversing of the table on long and short strokes, the heart-shaped cylinder cam is made conical, and by moving the roll upon the lever to a suitable position along the cam, the stroke can be reduced to any desired length.

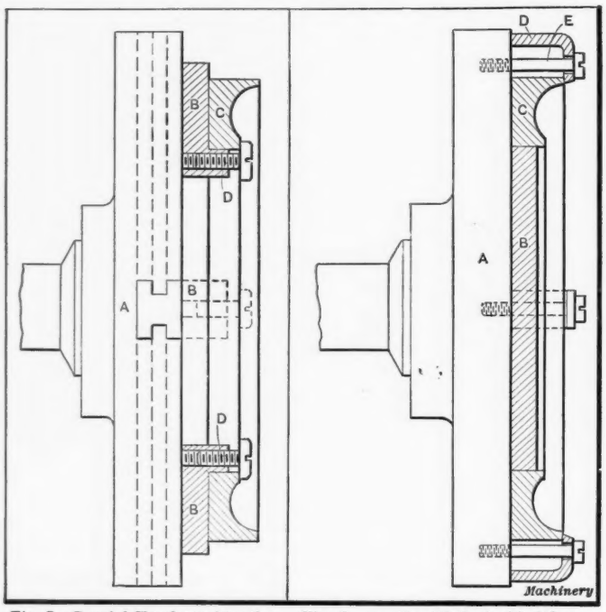


Fig. 5. Special Chuck used for the Grinding Operation shown in Fig. 4

Fig. 6. Another Method of holding this Class of Work

By thus securing an even table travel, an important improvement in internal grinding was made which enables these machines to grind internally without tapering or bell-mouthing.

Special Grinding Operations and Chucking Devices

In order to illustrate some of the possibilities of internal grinding and to show some of the chucking devices used in performing these operations, the accompanying illustrations and descriptions of modern internal grinding operations have been secured from leading automobile factories. Fig. 1 shows various automobile parts that are regularly ground in the Stevens-Duryea Co.'s factory in Chicopee Falls, Mass.

Grinding Tappet Rolls

Small tappet rolls like those shown on the end of the table of the grinding machine in Fig. 2, one of which is also shown in Fig. 1, are ground in an interesting manner on the Rivett No. 3 grinding machine. These rolls are used on the ends of the tappet rods and, when in use, are in constant contact with

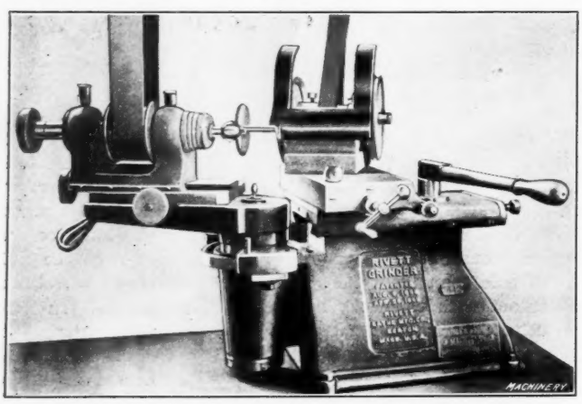


Fig. 7. Ball-grinding on the Rivett No. 5 Grinding Machine

the cams on the camshaft that operate the valves. In order to obtain satisfactory action of the valves it is necessary that the holes in these rolls be ground true with the end-faces. The rolls are first ground on these faces on ordinary surface grinding machines, and come to the Rivett grinding machines with their faces ground true and parallel.

By means of the special chucking fixture shown in Fig. 3, the rolls are chucked for the grinding of the bores, being held by their faces. This chucking device consists of a central shank *A* which fits into the spindle of a grinding machine after the manner of an ordinary draw-in collet. Over this shank, a sleeve *B* is fitted. A hole is bored in the end of this sleeve slightly larger than the hole in the tappet roll. By means of an inclined slot in the wall of the sleeve, acting in conjunction with a pin *C* driven into the shank, it is possible to hold the tappet rolls securely by the faces. This method of clamping is of the bayonet-lock order. Previous to clamping the tappet rolls in position, however, they are centrally located by means of a locating plug shown on the end of the table of the grinding machine at *D*, Fig. 2. The end of this plug is fitted to a central hole in the shank *A* of the chuck, and being a close fit for the hole in the tappet roll, the latter is thus located in a central position ready to be clamped and ground.

In grinding these holes, the grinding wheels used are of Norton make, J grade and No. 38 grit. The wheel spindle is operated at a speed of 17,500 revolutions per minute and the work spindle travels at the rate of 200 revolutions per minute. Limit gages are used for testing the work; these are shown at *E* and *F* on the end of the table of the grinding machine. The holes in these rolls are 0.4375 inch diameter and limits of but 0.0005 inch above or below are allowed. The thickness of the rolls is 7/16 inch. It will be noticed that the table and slides of the grinding machine are protected with

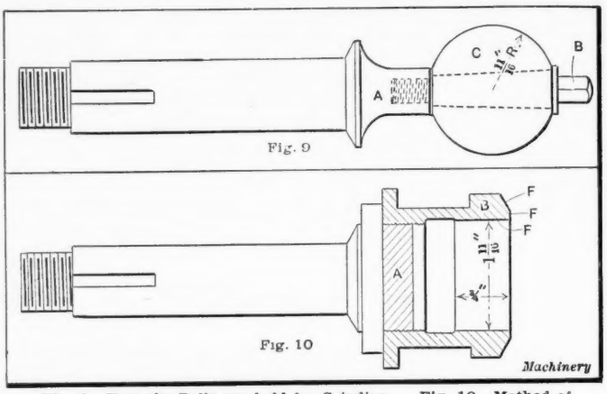


Fig. 9. How the Balls are held for Grinding. Fig. 10. Method of holding Steering Post Cones on the Grinding Machine

a wooden guard which keeps out a great deal of the emery and saves the bed from the wear occasioned by contact with wrenches and pieces of work.

Grinding the Races of Large Ball Bearings

In the shop of the Becker Milling Machine Co., Hyde Park, Mass., the races of large ball-bearings are ground on the No. 5 Rivett grinder. Some finished work is shown at the right of the machine in Fig. 4, and one of the pieces is shown mounted

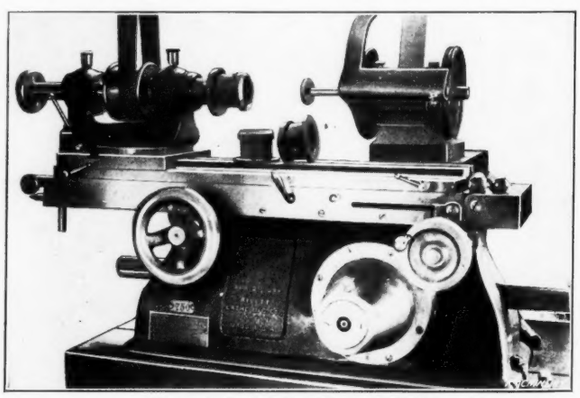


Fig. 8. Grinding Steering-post Cones

in the chuck of the machine. The method of holding the work is shown in Fig. 5. The rings are held in a chuck *A*, being gripped from the inside by means of chuck jaws *B* and held back against the jaws by means of four screws *D* whose heads extend over the inside edge of the work. In setting up the machine for this job the locating fixture shown on the end of

the machine in Fig. 4 is used. This locating fixture consists of a base *A* having, on its under side, a projecting stud that fits into a recess over the swiveling point of the work slide. At the top of arm *B* a thin steel disk of the proper radius is located, it also being at the correct distance from the center. By inserting the stud of this gage in the recess in the grinder bed, the chuck may be moved the proper distance from the swiveling point, thus insuring that the work will be ground at the right radius and to the proper diameter.

Fig. 6 is an illustration of the method used by the Stevens-Duryea Co., for holding similar ball bearing parts for grinding. This device consists of a faceplate *A* having a central stud *B* over which the ball bearing member is a close fit. For holding the work shown at *C* against the faceplate, four clamps *D*, held by screws *E*, are used. This work is ground at a spindle speed of 150 revolutions per minute, the wheel traveling at the rate of 17,500 revolutions per minute. Richardson elastic wheels, grain 80, grade 2R, are used.

Grinding Balls

One of the most difficult of grinding jobs is the grinding of a ball. This operation is shown in Fig. 7; the method of

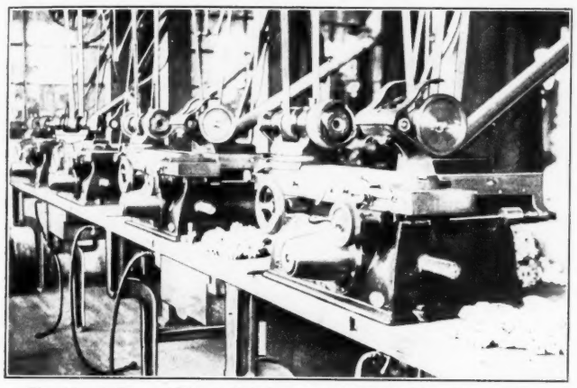


Fig. 11. A Row of Rivett Grinders in the Brown-Lipe-Chapin Gear Co.'s Factory, Syracuse, N. Y.

holding the balls for grinding is shown in Fig. 9. The holding fixture consists of a solid shank which is held in the grinding machine by the same method as an ordinary draw-in chuck. The end of this shank is tapped to receive set-screw *B* whose body is tapered to fit the tapered hole in ball *C*. After locating the work slide at the proper distance from the swivel post, it is easy to grind the balls spherical.

Grinding Steering-post Cones

The No. 3 Rivett grinding machine is also used for grinding steering post cones, an operation shown in the half-tone illus-

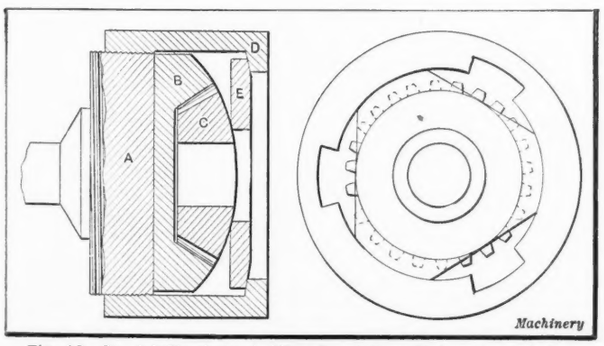


Fig. 12. Special Chuck for holding Bevel Gear Pinions for Grinding the Holes

tration Fig. 8. These cones are made from low-carbon steel and casehardened. The method of grinding these pieces is shown in Fig. 10. The work is held upon a threaded stud *A* which engages the internal thread in the piece to be ground, *B*. It is then a simple matter to grind the inside to size and also to grind the outside flange, finishing the three surfaces indicated by *F*. The work spindle revolves at the rate of 200 revolutions per minute and the wheel spindle at 17,500 revolutions per minute. The wheels used are of Norton make, being of J grade and 38-80 combination grit. The internal size must be accurate to within 0.001 inch. It is on work of this kind that the improved method of traversing the table is used to advantage, because it is essential that these pieces be ground straight—without bell-mouthing.

The Rivett Grinding Machine on Automobile Gear Work

The machines shown in Fig. 11 were photographed at the shops of the Brown-Lipe-Chapin Co., Syracuse, N. Y., where they are used for grinding the bores of small bevel gear pinions. These pinions are made from low-carbon steel and pack-hardened. As will be seen by referring to the grinding

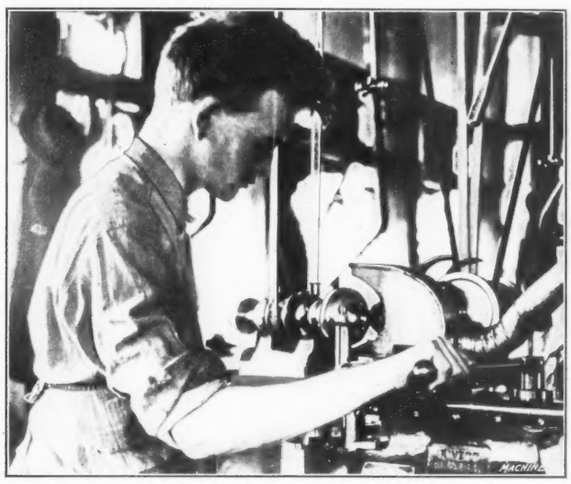


Fig. 13. Grinding the Spherical Faces of Bevel Gear Pinions

machine in the foreground, the gears are held by a special chucking device. This chucking arrangement is shown in the line illustration Fig. 12 and consists of a threaded base *A* held in the work spindle. Against the outside face of this base rests the lead matrix *B* which receives the bevel pinion *C*. A sleeve *D* is threaded onto the base and serves to draw the plate *E* down against the gear and matrix, pressing both against base *A*. In this position the bore of the pinion may be con-

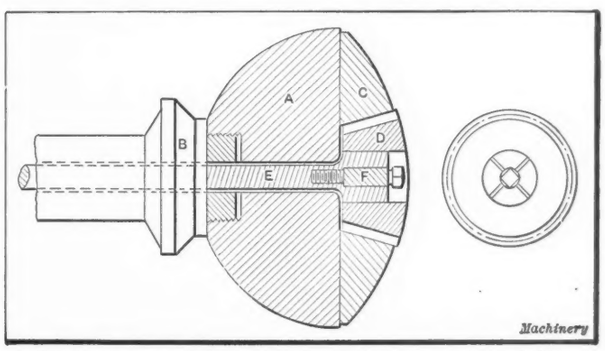


Fig. 14. How the Gears are held True with the Boss when grinding the Spherical Faces

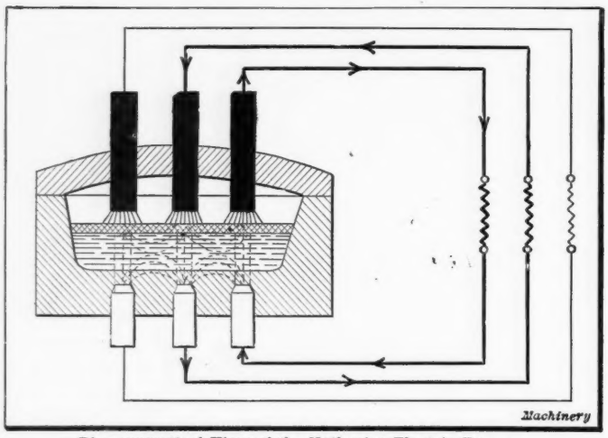
veniently ground and when finished may be removed by loosening the sleeve and removing the plate by means of the three openings in the flange of the sleeve. One operator looks after two machines and turns out 500 finished pinions per day. For cleaning out the chuck and its parts, compressed air is used; the air is supplied to the hose seen beneath the bench.

Grinding Spherical Faces of Bevel Gear Pinions

A second grinding operation is performed on the pinions mentioned above. This operation consists in grinding the spherical face, as shown in Fig. 13, the method of holding the work being shown in Fig. 14. A base *A* is threaded to the work spindle *B*. Against this base rests the lead matrix *C* in which the pinion is seated. This matrix is free to slide upon the face of the base *A*. By means of a split arbor *E*, expanded by set-screw *F*, the pinion is held by its bore, and after being gripped, is pulled back into contact with the matrix by the draw-in spindle integral with the expanding arbor. The faces of these pinions must be ground very accurately, a variation of 0.0005 inch from standard being the limit allowed. An average day's production is 650 gears.

IMPROVEMENTS IN ELECTRIC FURNACES

A paper was recently read before the Iron and Steel Institute of Great Britain by Mr. H. Nathusius on "Improvements in Electric Furnaces and their Application in the Manufacture of Steel." In this paper the author first took up the induction furnace and then the arc furnace, calling attention to the advantages and disadvantages of each. One of the disadvantages of the induction furnace is that the electrically induced heat can only be generated in the metal bath and not in the slag, which must, therefore, be heated indirectly by the underlying metal. It is, however, uneconomical to heat the slag by means of molten steel as the melting point of the latter is lower than that of the slag. Consequently, a higher



Diagrammatical View of the Nathusius Electric Furnace

temperature has to be imparted to the metal bath than would otherwise be necessary.

The objection to the arc furnace, while it otherwise has exceptional advantages, is that while it heats the slag and the surface of the charge exceedingly well, it does not offer as good a means for heating the charge itself as does the induction furnace. Mr. Nathusius has, therefore, for many years made a special study of arc furnaces and their working conditions, and while he was soon obliged to acknowledge the great advantages of electric arc heating, the idea occurred to him at the same time that it might be possible to combine the advantages of the arc furnace (good heating of the slag) with the advantages of the induction furnace (heating in the charge itself), and thus avoid the disadvantages of both systems. It became evident to him at once that the electric current offered the possibility of applying heat not only at the surface of the charge, but also at any part where an intense heat is required, such as in the charge itself and especially at the bottom of the furnace. He also recognized that the natural method of heating consisted in applying heat not from above but below. If this could be effected by some simple means a substantial advantage over other arc furnaces would be gained.

In order to meet these requirements, he has constructed a furnace which consists of a combination of an arc and resistance furnace, as indicated diagrammatically by the accompanying engraving. The characteristics of this furnace are that it has three carbon electrodes above the surface of the charge which project through the roof into the furnace, and three or a multiple of three bottom electrodes of mild steel rammed in the hearth. The upper as well as the bottom electrodes are arranged in an equilateral triangle. In this way as much as possible of the energy required for a particular furnace may be transferred to the bottom of the bath and the method of heating thus approximates that of an induction furnace. By the aid of special means for the distribution of the current, it is possible to transfer a greater or smaller amount of energy to the arcs at the surface or to the bottom electrodes, as desired. The current employed is a three-phase alternating current.

The three surface carbon electrodes are connected to the outer terminals of the secondary windings of the furnace transformer and the three bottom electrodes are connected to the three inner terminals of the secondary coil. The three inner terminals of the transformer are obtained by separating the windings at the neutral point where the three secondary windings of an ordinary three-phase transformer are connected. By this means the neutral zone—it is permissible for the sake of clearness to thus represent the electric conditions—is transferred to the bath itself and the current must gravitate from all points of supply toward this neutral point. In other words, the current, though supplied from a single source only, is forced to flow not only between the upper and bottom electrodes, but also between any upper electrode and any bottom electrode. It is thus possible, with a single source of current, to heat the charge in all parts, provided that its resistance is sufficiently high or that the current is strong enough to produce sufficient heat in the charge when the resistance is low.

INTERESTING PRINCIPLE APPLIED TO A BORING JIG AND PLANING FIXTURE

An interesting principle applied to boring and planing jigs is shown in the accompanying illustrations. Fig. 1 shows a jig which was made for boring the holes in the head of the boring machine built by the Cleveland Machine Tool Works, Cleveland, Ohio. The jig consists essentially of a planed and grooved base to which brackets carrying bushings for guiding the boring-bar are attached. The principle followed in boring these brackets for the guide bushings is illustrated in Fig. 2.

The bracket *A*, at the extreme right in Fig. 1, is slid along to the other end of the fixture, as shown in Fig. 2, and then the other bracket *B* is clamped to the right of it. This is done so that the lugs at the base of the brackets do not interfere with clamping them close together. This arrangement facilitates the accurate boring of the holes in the brackets, both laterally and vertically. Slight errors in alignment existing when the holes are bored are greatly reduced when the brackets

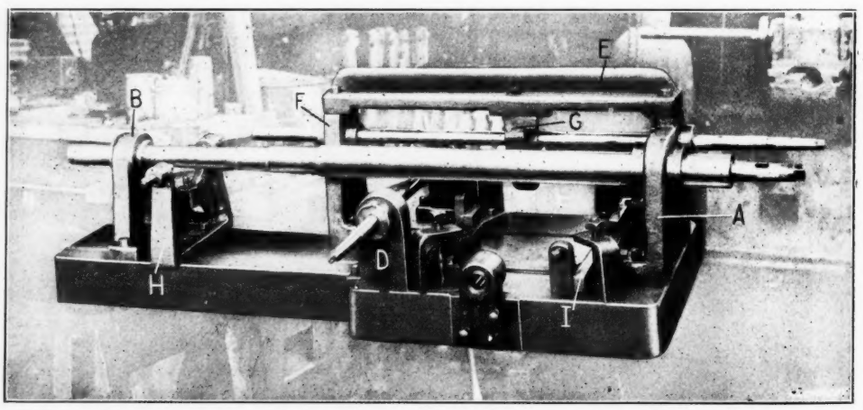


Fig. 1. Boring Jig used by Cleveland Machine Tool Works for boring Machine Heads

are set at opposite ends of the base. In fact, the principle insures that the centers are practically the same distance from the base and in line with the axis of the base slot or groove when they are placed in their respective positions on the fixture. The brackets, of course, are provided with lugs formed on their bases, which accurately fit in corresponding grooves in the jig base.

The bushing guide holes in the bracket *A* and the corresponding holes in the other bracket were at the vertices of a triangle, as is shown at *C* in Fig. 2. The lines joining their centers were neither parallel to the platen nor to the vertical travel of the boring machine head. So the lengths of the bases a, a_1 and altitudes b, b_1 of the triangles were computed to obtain the correct settings of the boring machine head for the various holes, and the settings of the head and platen were accom-

plished by means of the scales and verniers regularly supplied on these boring machines.

When the three holes in the two brackets were bored, the fixture was swung around to bore the two side brackets, one of which is shown at *D*, Figs. 1 and 3, with a boring-bar in place. The center lines of the four brackets *A*, *B*, *D*, and the one on the far side (not shown) must be at right angles. The bridge *E* was bolted and doweled to the brackets *A* and *F*, and then the center bracket *G* supported by the bridge was bored and bushed.

To clamp the work in the fixture, it is adjusted centrally in the saddle *H* by means of the screws. Then the wedges *I* under the front and rear of the right-hand end of the work are adjusted, clamped and the screws in the saddle tightened, as illustrated in Fig. 3. This gives a three-point bearing or support. To hold the work rigidly in position the wedges to the right of the center of the casting at the front and rear are adjusted and clamped. This method of clamping the casting prevents straining it, and holds it rigidly. When the wedges were first considered as a means of adjusting the work, it was thought that they would move under the cut, and thus require adjusting screws to hold them. This, however, was not the case, for after three years' service, the wedges have not been found to slip. The taper on the wedges is three-quarters inch per foot. Thirty-three boring and facing operations and six milling operations are performed on the head casting before it is unclamped from this combined jig and fixture.

This same principle of aligning the brackets applied to a planing jig is illustrated in Fig. 4, the brackets *J* and *K* at each end being bored in a manner similar to those of the jig illustrated in Figs. 1, 2 and 3. The bar *L* is employed to set the casting so that the face to be planed shall be parallel with the axis of the hole in which the bar is placed.

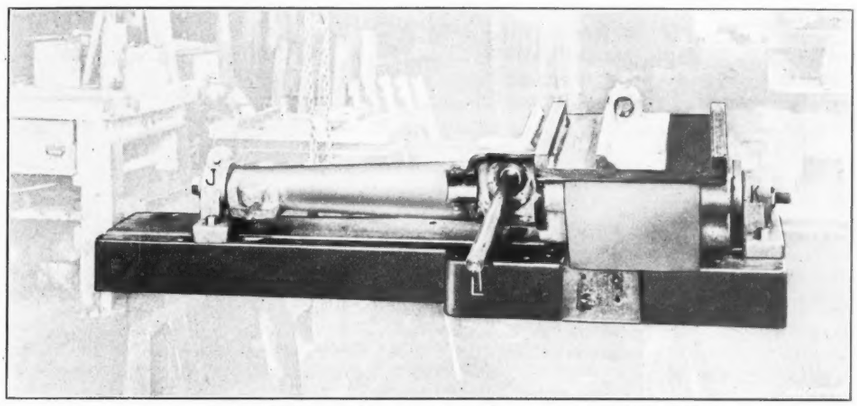


Fig. 4. Planing Fixture for Heads, made on Same Principle as Jig in Fig. 1

* * *

The Hamburg-American liner *Imperator*, for the time being the largest ship afloat, was launched in May at the Vulcan Works in Hamburg. The length of the new vessel is 880 feet and the width, 98 feet. The gross tonnage is about 51,000 tons and the speed at sea will be 22 knots. It is equipped with four classes for passengers and can carry 700 first class, 600 second class, 940 third class, and 1750 fourth class passengers. The crew will number about 1100 so that the total number of persons on board with the accommodations fully used will be about 5100. As an indication of the enormous size of the fittings of the vessel, it may be mentioned that the weight of the anchor and chain is about 225 tons (of 2000 pounds). The diameter of metal in the individual links in the anchor chain is about four inches. One hundred life-boats will be provided on the vessel and the latest design of davits has been adopted. The electric lighting installation includes about 10,000 lamps. The vessel will be driven by four four-blade propellers of 16½-foot diameter, which are driven by steam turbines at a normal rate of 185 revolutions per minute.

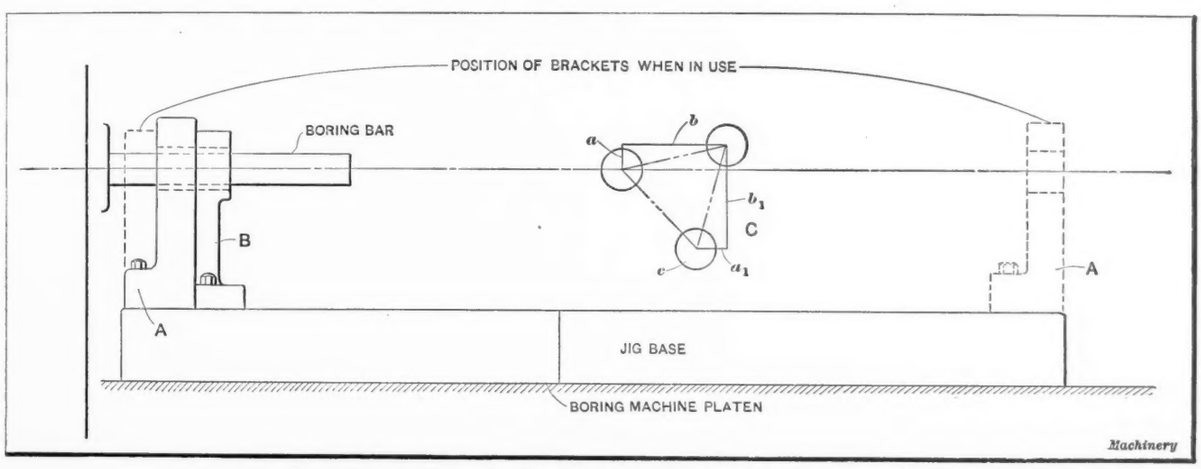


Fig. 2. Diagram illustrating Principle of Construction embodied in Boring Jig

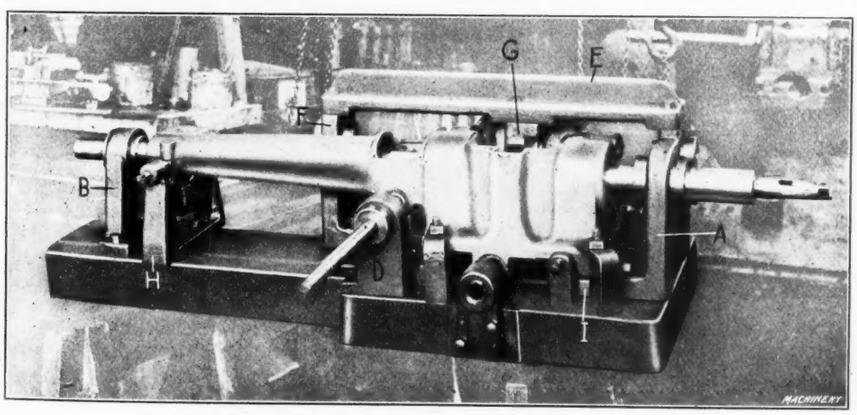


Fig. 3. Boring Jig with Head Casting clamped in Place ready for Boring

* * *

It is a whole lot easier to find fault with a foreman than it is to fill his place.

PROPOSED CHANGES IN PATENT LAWS

Several bills have been introduced in Congress during the present session relating to changes in the patent laws. In one of these, introduced by Mr. Oldfield (House Bill No. 23,417), a number of clauses are included which are of considerable interest, some of which are quoted in the following. Section 17 relates to the term of patents and their compulsory working, and reads as follows:

"Sec. 17 (R. S., sec. 4884). Every patent shall contain a short title or description of the invention or discovery correctly indicating its nature and design, and shall have annexed thereto and made a part thereof a copy of the specification, claims, and drawings of the application therefor, to which it shall refer for the particulars of the invention or discovery, and contain a grant to the patentee, his heirs or assigns, of the exclusive right to make, use, and vend the invention or discovery throughout the United States and all Territories and possessions under the jurisdiction thereof, for the term of seventeen years. But every patent granted for an invention shall be so limited as to expire nineteen years from the date of the filing, in this country, of the application upon which the patent was granted, exclusive of the time actually consumed by the Patent Office or the courts in considering the application, and where the application has been involved in interference, of the actual time in which it has been so involved, and in no case shall the patent be in force more than seventeen years.

"If at any time during the term of the patent, except the first four years, the patented invention shall not be manufactured, or the patented process carried on within the United States, its Territories, or possessions aforesaid to an adequate extent by the owner thereof, or by those authorized by him, then any person demanding it shall be entitled to a license from the owner of the patent to manufacture the invention or to carry on the patented process, unless the owner shall show sufficient cause for such inaction. Upon the refusal of such a license by the owner of the patent, the person seeking such license may apply to the district court, in the district wherein the owner has a residence or an established place of business, to compel the granting of such license. The court shall thereupon hear the person applying for said license and the owner of the patent, and, if the court is satisfied that the reasonable requirements of the public in reference to the invention have not been satisfied by reason of the neglect or the refusal of the patentee, his legal representatives, or those authorized by him to make, use, or vend the invention, or to grant licenses to others on reasonable terms to make, use, or vend the same, said court shall issue an order requiring the owner of the patent to grant a license to the person applying therefor in such form and upon such terms as to the duration of the license, the amount of royalties, security for payment, the period within which the patented invention shall be manufactured or the patented process carried on, and otherwise, as the court, having regard to the nature of the invention and the circumstances of the case, deems just.

"From the order of the district court granting or refusing to grant such a license, appeal may be taken (by the party aggrieved) to the circuit court of appeals in the same manner and form as in other cases arising under the patent laws: *Provided*, That the citizens of any country which by treaty, convention, or law provides that the manufacture of the patented invention or the carrying on of the patented process in the United States shall be equivalent to the manufacture or the carrying on of the process in such country, will be considered to have sufficiently complied with the requirements of this section if the invention is manufactured in said country within the period heretofore mentioned.

"If at any time during the life of a patent a material and substantial improvement shall be patented, the manufacture of which would be an infringement of the original patent, the owner of the improvement patent may apply to the district court in the district wherein the owner of the original patent has a residence or an established place of business to compel the granting of such a license as will enable the improvement to be manufactured. The court shall thereupon hear the respective parties, and if the court is satisfied that the improvement is of such a material and substantial nature that the reasonable requirements of the public demand that it should be manufactured and sold, the court shall issue an order requiring the owner of the original patent to grant a license to the owner of the improvement patent in such form and upon such terms as to the duration of the license, the amount of royalties, security for payment, the period within which the patented invention shall be manufactured or the patented process carried on, and otherwise, as the court, having regard to the nature of the original invention and improvement and the circumstances of the case, deems just.

"From the order of the district court granting or refusing such a license appeal may be taken by the party aggrieved to the circuit court of appeals in the same manner and form as in other cases arising under the patent laws."

Section 19, relating to the conditions under which applications must be made, reads, in part, as follows:

"Any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof, not known or used by others in this country before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than two years prior to his application, and not in public use or on sale in this country for more than two years prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law, and other due proceeding had, obtain a patent therefor."

Section 32, relating to the use of patented articles by persons to whom the patentee has sold or otherwise transferred the right to use or sell the article, reads as follows:

"Sec. 32 (R. S., sec. 4899). Every person who purchases of the inventor or discoverer, or, with his knowledge and consent, constructs any newly invented or discovered machine, or other patentable article, prior to the application by the inventor or discoverer for a patent, or who sells or uses one so constructed, shall have the right to use, and vend to others to be used, the specific thing so made or purchased without liability therefor.

"Any person who purchases of the owner of a patent, or of any interest therein, any machine, manufacture, or composition of matter covered by such patent, shall have the unrestricted right to use, vend, or lease to others to be used the specific thing so purchased without liability to action for infringement; and it shall not be lawful to insert a condition in any contract relating to the sale, lease, or license to use any article or process protected by a patent or patents, the effect of which will be to prohibit or restrict the purchaser, lessee, or licensee from using any article or class of articles, whether patented or not, or any patented process supplied or owned by any person other than the seller, lessor, or licensor or his nominees; and it shall not be lawful to insert a condition in any contract relating to the sale, lease, or license to use any article or process protected by a patent or patents, the effect of which will be to require the purchaser, lessee, or licensee to acquire from the seller, lessor, or licensor, or his nominees, any article or class of articles not protected by the patent, and any such condition shall be null and void as being in restraint of trade and contrary to public policy."

Two bills have also been introduced in The House of Representatives, by Mr. Thayer, being, respectively, House Bill 11,380 and 11,381, differing only in some minor details and in respect to the penalties imposed for violations. These bills would legalize contracts to the effect that users of patented articles must buy all such supplies as are used in connection with the operation of the patented article from the owners of the patent. Bill 11,380 reads, in part, as follows:

"No person, firm, corporation, or association engaged in interstate commerce having any interest, whether as owner, proprietor, beneficiary, licensee, or otherwise, in any tool, implement, appliance, or machinery shall, directly or indirectly, in making any sale or lease of or any license to any article, restrain or attempt to restrain or prevent the vendee, lessee, or licensee from using any tool, implement, appliance, machinery, material, or merchandise not furnished by the vendor, lessor, or licensor, whether by making any condition or provision, express or implied, against such use by a term of any sale, lease, or license to use, or by requiring any obligation, express or implied, against such use from the vendee, lessee, or licensee of the article, or by imposing any restrictions upon the use of the article sold, leased, or licensed, or by making in the price, rental, royalty, or other terms of any such sale, lease, or license any discrimination based upon whether the vendee, lessee, or licensee uses or purchases any such tool, implement, appliance, machinery, material, or merchandise or not, or by any other means whatsoever: *Provided, however*, That nothing in this Act shall be construed to prevent any such vendor, lessor, or licensor from requiring that during the continuance of any letters patent on any such article no component or constituent parts of the tool, implement, appliance, or machine required for use thereon be purchased except from such vendor, lessor, or licensor, or from requiring that material to be used in the operation of any machine must be obtained from the vendor, lessor, or licensor."

* * *

A HANDY SURFACE PLATE

A convenient arrangement for holding a surface plate is used in the shops of the Cutler-Hammer Mfg. Co., Milwaukee, Wis. It consists of a heavily built and well braced table, fitted with good sized castors. The surface plate is supported on this table, which can be wheeled to any point where it may be wanted. Taking the surface plate to the work often eliminates considerable trucking of the work.

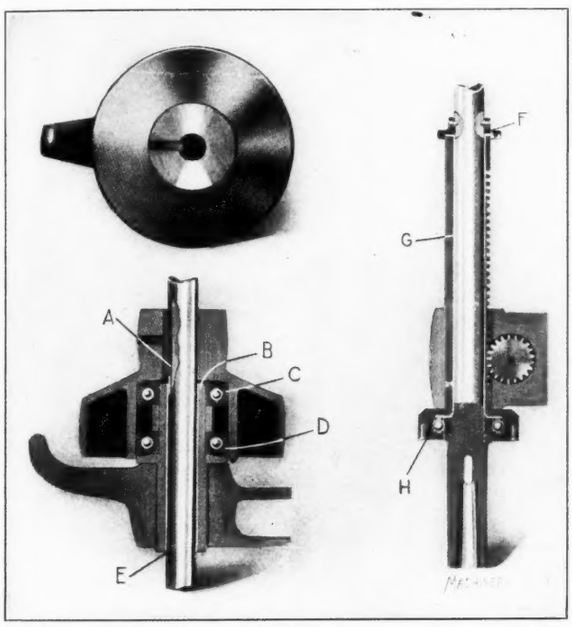
LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

TOO MANY PATENTS A HINDRANCE TO PROGRESS

The article in the May number of MACHINERY on "Too Many Patents a Hindrance to Progress," raises a very interesting question: What is, in equity, a reasonable basis for the granting of patent rights? The writer of the article mentioned uses as a peg on which to hang his argument the granting of patents on the application of ball bearings to sensitive drilling machine spindles, and suggests that such patents would be valueless were it not that the maker's name and position acted as a watch dog against encroachments.

As the article in question hails from England, it appears as though allusion were made to the construction of the Alfred Herbert sensitive drilling machine. If this is so, the present



Sectional Views showing Alfred Herbert Ltd., Coventry, England, Sensitive Drill Ball Bearings—A, spindle centered by this hole; B, fixed sleeve; C and D, pulley bearings; E and G, clearance, no sleeve bearing; F, dust cap, no thrust bearing; H, the only spindle bearing

writer has no hesitation in asserting that, although the particular construction of this machine—in so far as the spindle is concerned—entails but a particular arrangement of ball bearings, there exists in this instance extraordinarily good grounds for the granting of a patent.

Novelty is a good basis, and novelty may exist in an arrangement. If mere arrangements are to be barred, then the great majority of inventions could not form suitable subjects for patents. In the drilling machine in question the spindle construction is decidedly novel—nay, more—bold. It is indeed probable that had this particular firm not put this arrangement into use, no one else would have been sufficiently bold to risk such an arrangement. As a matter of fact, ball bearing manufacturers prophesied a failure. The firm, however, in introducing it, knew from experiments that success would be assured; and, after all, if ball bearing manufacturers had but given the matter the careful attention it deserved, their own previous statements would have been sufficient evidence. Most of the catalogues of these firms recommend that journal bearings should not be subjected to more end thrust than 25 per cent of the journal pressure. This statement implies that if a journal bearing be subjected to end thrust only it would be sufficient to choose one large enough, and success would be assured. Here is now an individual who has realized this fact for the first time. Should he be debarred from obtaining a patent? If so, where must a line be drawn, in view of the fact that today the ground of mechanisms has been so covered as to make it almost impossible to invent anything entirely new?

To enable readers to judge of the merits of the case, the spindle construction is shown in the accompanying engraving. The particular advantages claimed are: First, entire absence of journal friction; note the clearance between spindle and pulley support and rack sleeve; second, cheaper construction; any other method of obtaining the same end is only possible by having one bearing to take the thrust from drilling, another to bear the weight of the spindle, and still another for the journal load; third, little necessity for oil beyond the initial supply (grease is used); the makers claim that the machine needs oiling but once a year; fourth, no adjustment necessary, the construction rendering adjustment impossible. Cone bearings—a possible construction—are by no means as efficient, and wear renders some provision for adjustment imperative.

It might be interesting to cite the fact that on machines supplied to the makers of the S. K. F. bearing, these bearings were fitted and were successful. These machines have been on the market now some four years, probably a thousand or more having been turned out in this time. This is in itself sufficient evidence of success.

The following particulars will give some idea of the power of the machine. The spindle, 1 inch in diameter, is driven by a 1½ inch belt. Without appreciable slip, ⅞ inch holes, 1 inch deep, may be drilled in cast iron (hardness: 238 Brinell) at 600 revolutions per minute in four seconds; and in machinery steel (52,000 pounds tensile strength) at 900 revolutions in 7 1/5 seconds. The accompanying table shows the complete range of the possible output:

The writer, who has had the pleasure of operating one of these machines, can assert that in drilling holes up to about ½ inch diameter, no matter what amount of weight is applied at the lever, it is impossible either to break a drill or slip the belt. In the case of the larger holes, the belt is the limiting

TABLE OF TIME FOR DRILLING ON ALFRED HERBERT SENSITIVE DRILLING MACHINES

Cast Iron			Machinery Steel		
Diameter of Drill	Speed of Drill	Time to Drill 1 Inch Deep, Seconds	Diameter of Drill	Speed of Drill	Time to Drill 1 Inch Deep, Seconds
¼	2050	1⅗	¼	2050	2⅔
½	900	2	½	900	3⅓
¾	900	2	¾	900	4
1	600	2½	1	900	5⅗
1¼	600	3	1¼	900	6
⅞	600	4	⅞	900	7⅕

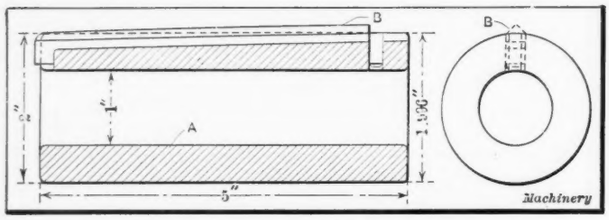
factor, but then a machine designed to drill ⅞-inch holes at the same rate as ¼-inch holes, could no longer be termed a sensitive machine. If made for ⅞-inch holes, it would be too cumbersome for ¼ inch. If it were not for the belt slipping, the journal "thrust" bearings would probably fail on the larger holes.

Didsbury, Manchester, England. FRANCIS W. SHAW

BABBITT EXPANDER AND OIL-GROOVE FORMER

Considerable trouble is met with in babbitting solid bearings when a shaft or mandrel is used as a core. When babbitt is cast around a mandrel it shrinks and grips the latter, at the same time becoming loose in the casting. In order to overcome this difficulty and at the same time provide for an oil groove in the babbitt lining, the device shown in the accompanying illustration was made. It consists of a piece of machine steel *A* which is turned and bored to the dimensions indicated, one end being 0.004 inch smaller in diameter than the other end, so as to make it easier to knock it out when fast in the babbitt. The so-called expander *B* is a piece of ¼-inch square key steel, bent over at one end, and having an angular top of about 90 degrees included angle. This piece

fits loosely in a milled slot in the sleeve *A*. The device is used as follows: A 1-inch shaft is placed through the hole in the sleeve, and the sleeve with its key is turned on the shaft until the key is in the position where the oil groove is required in the babbitt bearing. Now cast the babbitt around



A Babbitt Expander and Oil-groove Former

this sleeve and when it has set and tends to shrink away from the casting, pull the sleeve with its key out toward the left. The babbitt is then compressed upward and sideways by the key, as it passes toward the left, just enough to force it firmly into the cast iron surrounding it. J. S. B.

FIXTURE FOR FACING GAS ENGINE CYLINDERS

The fixture shown in Fig. 2 is fitted to a drill press and is used for finishing the inside face *A* of the boss of a gas engine cylinder as shown in Fig. 1. This face *A* is located in such a position that it is difficult to machine, and it is impossible to do so with a side milling cutter, so some other means had to be provided to accomplish the work. About ⅜ inch of material is to be removed from the boss.

Referring to Fig. 2, the frame of the fixture *A* is clamped to the spindle sleeve of the drill press by two bolts which are inserted through the holes in the upper part of the frame. The bar or spindle *B* is provided with a Morse taper shank which fits in the spindle of the drill press and is driven by it. The lower boss of the bracket *A* is bored out in line with the spindle of the drill press, and is bushed with a hardened and ground steel bushing *C*. Inserted in this bushing *C* is another hardened and ground bushing *D* which is prevented from rotating by means of the screw *E* fitting in the keyway cut in the bushing. Inside of the bushing *D* is a cam *J*, which is a good running fit on the bar *B*. This cam is provided with a

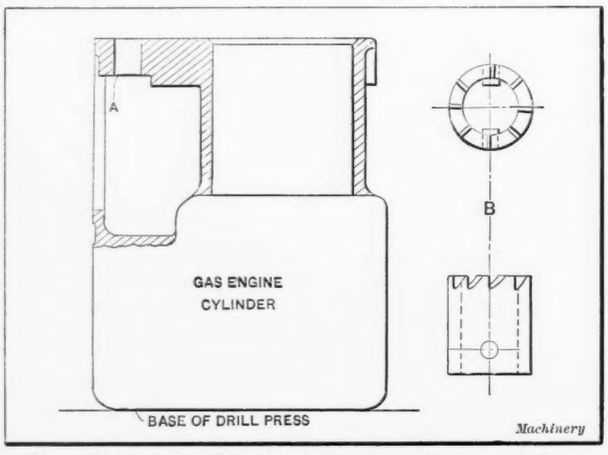


Fig. 1. The Gas Engine Cylinder and the Cutter used in Facing the Boss

spiral groove having a lead of ¾ inch to one turn. Fitting in the spiral cam groove is a screw *F* screwed into the bushing *D*. To locate this screw in the bushing *D*, a hole *K* is drilled in the bracket through which the screw is inserted; then the bushing is rotated through an angle of 90 degrees to bring the screw into the position shown in the illustration. The lower end of the cam *J*, which is cylindrical in shape, rests on the top face of the cylinder casting and is operated by means of a handle *G* screwed into it. A thrust ball bearing *H* is interposed between the top face of the bushing *D* and the shoulder on the bar *B* to reduce the friction between these surfaces.

In operation, the spindle of the drill press with the fixture attached to it is lowered until the spindle *B* is located in the hole in the cylinder casting. Of course the cutter cannot be placed on the spindle *B* until the latter is located in the hole in the casting. When this is done, the cutter, as shown at *B* in Fig. 1, which is provided with two pins is slipped onto the end of the spindle *B*, the pins fitting in vertical grooves cut in the spindle. These grooves terminate in additional grooves, cut part way around the circumference, so that it is a simple matter to push up the cutter, turn it around, and thus lock it in position. These grooves are cut in such a manner that the cutter when in operation will be held securely.

When the cutter *I* is put in position on the spindle *B*, the operator grips the handle *G*, turning the cam in the direction indicated by the arrow. This movement of the cam imparts an upward motion to the bushing *D*, which, in turn, raises the spindle *B* and also the spindle of the drill press and the fix-

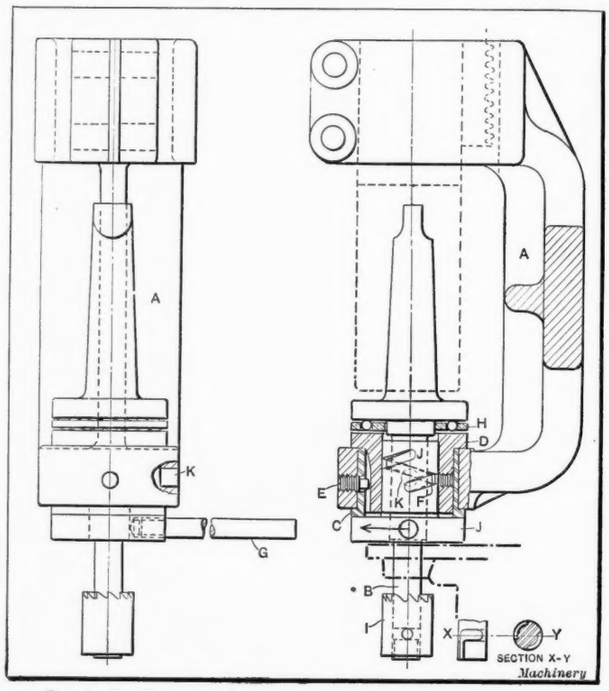


Fig. 2. The Fixture used in Facing the Boss, showing the Manner in which it is applied to the Drill Press

ture which is attached to it, the spindle being disconnected from the worm. This action brings the cutter in contact with the work, when the boss can be faced to the desired distance by simply continuing the movement of the handle *G*. The idea in designing a fixture of this type was to equalize the pressure on the casting while the facing operation was being performed. By constructing the fixture in this manner, the whole weight of the fixture is thrown down upon the bottom of the cylinder, so that the action of the cutter up against the cylinder causes an almost equal and opposing force at that point.

Detroit, Mich. WALTER F. WAGNER

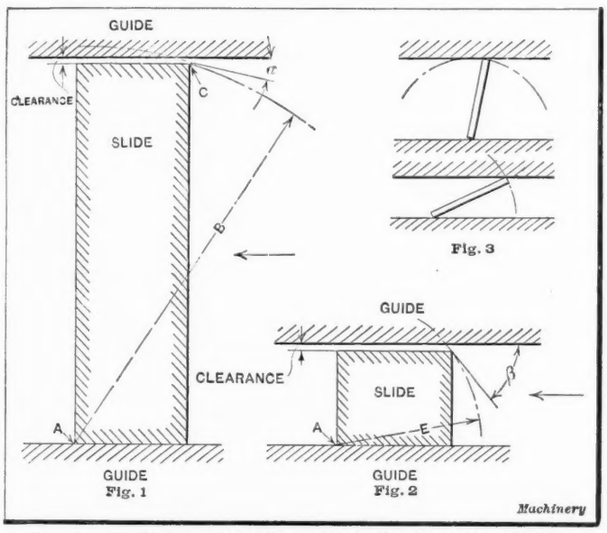
WIDE VS. NARROW GUIDES

The writer has been greatly interested in the discussion of wide versus narrow guides and believes that the ground has not yet been quite covered. Personally, he cannot agree with the conclusions of either Mr. Burley or Mr. Millar, and must endorse the view expressed in the editorial note on the subject accompanying Mr. Burley's article in the April number. Of course one must concur with some of Mr. Millar's remarks, as for example, his conclusions Nos. 3 and 4, but the conclusions Nos. 1 and 2 the writer does not think are yet proved, still holding the idea that the advantages to be gained by a narrow guide are a direct function of the relation of the slide's width to its length. His reasons for so thinking are substantially those advanced in the editorial note just referred to.

Perhaps the accompanying illustrations will make the idea plainer and introduce one element not yet touched upon, and upon which perhaps the whole matter hinges. When a slide advances between parallel guides, cross-wind may be caused

by an obstruction to one edge of the slide or by the eccentric application of the propelling force. The simplest case of an obstruction would be some grit at one edge of the slide as at *A*, Figs. 1 and 2. That edge is retarded and the diagonally opposite corner at once rises the clearance distance and strikes the guide. In other words, the slide in Fig. 1 when retarded at *A* tends to rotate with point *A* as a center, and the edge *C* describes a circular path with a radius *B*, the action being limited by the amount of the clearance.

Assume that the wide and narrow guides in Figs. 1 and 2 have the same clearance; when the point *C* of the wide guide approaches the upper guide it will do so along a certain arc, as illustrated in Fig. 1. By drawing a tangent to this arc at its point of intersection with the line of the upper guide, we form the angle α (see Fig. 1) or β (see Fig. 2) which angle may be called the "angle of approach." This angle determines the binding effect. If the angle is small, as seen in the wide guide, the friction becomes great, but if the angle is large, as in the narrow guide, the binding effect is minimized. It is really a toggle action in an unusual form. In Fig. 3 is shown a bar or gage between two walls. The binding effect is greatest when the bar can be placed in a nearly vertical position between the guides, as in the upper part of Fig. 3, while the binding effect is practically nil when the bar is at an inclination as shown in the lower part of Fig. 3. The writer believes that every mechanic who has noted the ease with which a plug gage, say ½ inch in diameter, 1 inch long, can be inserted in a hole and pushed along it, and who has also noted the extreme difficulty experienced when the gage happens to be of the same length, but say about 6 inches in diameter, will agree that the theory just presented is borne out by practice.



Figs. 1 to 3. Diagrammatical Views illustrating the Action of Slides having Wide and Narrow Guides

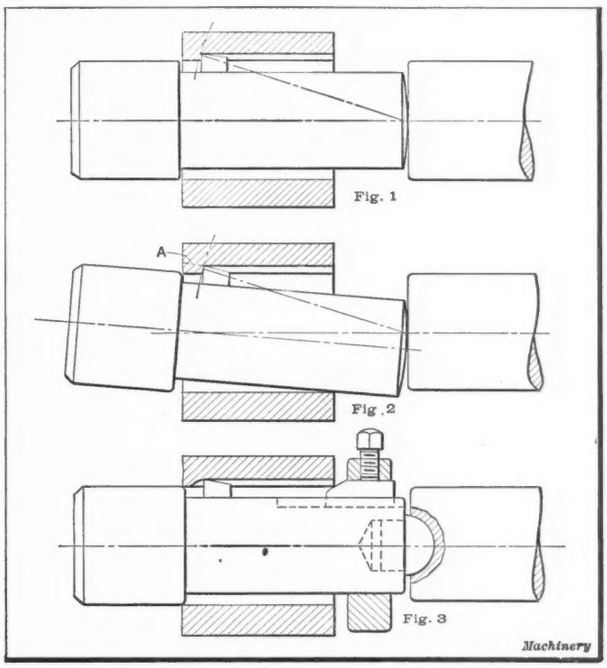
S. M. RANSOME

Cleveland, Ohio.

CUTTING OIL-GROOVES IN BUSHINGS

In the article entitled "Cutting Oil-grooves in Bushings," published in the May, 1912, number of MACHINERY, an appliance similar to one which the writer saw a few years ago, but which proved to be a failure, is illustrated and described. The construction of the appliance seen by the writer is indicated in Fig. 1. This device was arranged to be used on a turret lathe, the cutter and holder being pressed in by a plain bar fixed in one of the turret holes. Instead of operating as intended, however, the shank assumed the position shown in Fig. 2 immediately after the guiding part of the cutter holder had passed out of the bushing. The cutter, instead of slipping out of the work, would proceed to cut a groove, the bottom of which would be at an angle as indicated by the dotted line *A*.

Now, even if the end of the shank had been flat instead of rounded, the cutter would not have left the work, but would have proceeded to cut the groove clear through. An examination of Fig. 1 will show that the cutting face of the cutter cannot possibly come out of the groove, as it is in effect undercut in relation to the path of its travel when retreating from the groove, as indicated by the circular arc shown. In order to try to improve matters, a ball and socket joint and an adjustable wedge, as shown in Fig. 3, were fitted, with the idea of compelling the cutter to leave the groove. This arrangement was fairly successful, but owing to the fact that the tool was so short, considerable force was needed, tending to damage the mouth of the hole.



Action of Device for Cutting Oil-grooves in Bushings

Another point that might be mentioned is that the tool as shown in Fig. 1 began to tilt long before the guiding portion left the hole, and the back end of the hole was, therefore, somewhat mutilated.

The writer would like to know if your former contributor had to use any special appliances in order to insure success in his arrangement. The device shown in the accompanying illustration was abandoned and substituted by a simple slotting operation in an ordinary slotting machine. SLOTTER

SPHERICAL TURNING DEVICE

The lathe attachment shown in the accompanying illustrations, Figs. 1 and 2, and described in the following, has given good results for a long time. It was designed for the requirements met with in turning balls or other spherical parts which must have accurate dimensions, an operation which is rather difficult to carry out by hand. The appliances on the market for the purpose failed to give accurate results. The device shown is strong and capable of producing a practically

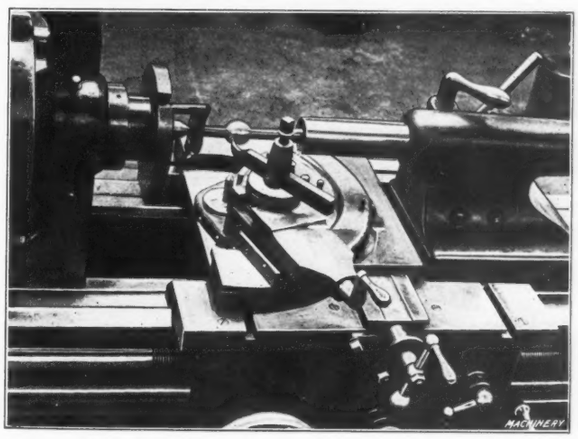


Fig. 1. Spherical Turning Device for Accurate Turning

exact sphere. It is applied to an 18-inch Hendey-Norton lathe.

In Fig. 2, *B* is a cast-iron plate which is fixed directly on the dovetail slide of the lathe carriage by means of taper gibs *C*. The dovetailed groove of the plate *B* has parallel sides, and the two taper gibs, which have the same amount of taper, are introduced one from the front and the other from the back, so as to compensate for the taper. By being attached in this way, plate *B* rests rigidly on the carriage and can be fitted and taken out very easily, or adjusted to any position of the dovetailed guide. On plate *B* is fitted and rotates the turntable *D* provided with a dovetailed groove for the toolpost *P*. The turntable rotates on pivot *E*, which is fixed to plate *B* by four screws. The turntable is also guided by a circular gib *F*.

A circular rack *G* is fixed with screws in a groove provided for it; this groove is protected from chips as indicated. Rack *G* meshes with gear *H* which is fastened by a key to a worm-wheel which, in turn, is carried by shaft *I*. Plate *B* is also provided with two brackets carrying the screw *L* of the carriage. This screw meshes with the worm-wheel to which the bevel pinion *H* is fastened. The circular movement of turntable *D* is thus obtained from the carriage screw *L*, and, as this screw, through the design of the lathe, is provided with several speeds, a suitable feed can also be chosen for the spherical attachment. Stops *M* and *N* are provided in order to prevent the turntable *D* from swiveling too far. Felt packing is used to keep the working surfaces clean and free from dirt and chips. The pivot *E* has a hole in the center which is carefully ground to fit pin *O*. This pin is used for rapidly locating the carriage with relation to the center of the ball to be turned. It can be withdrawn during the operation. If particularly accurate results are required, the rotating axis of the fixture must intersect the axis of the lathe spindle. The fixture is then first located by means of pin *O* and may be adjusted by subsequent trials until a perfect sphere is formed. The form and position of the tool have no bearing on the accuracy of the work.

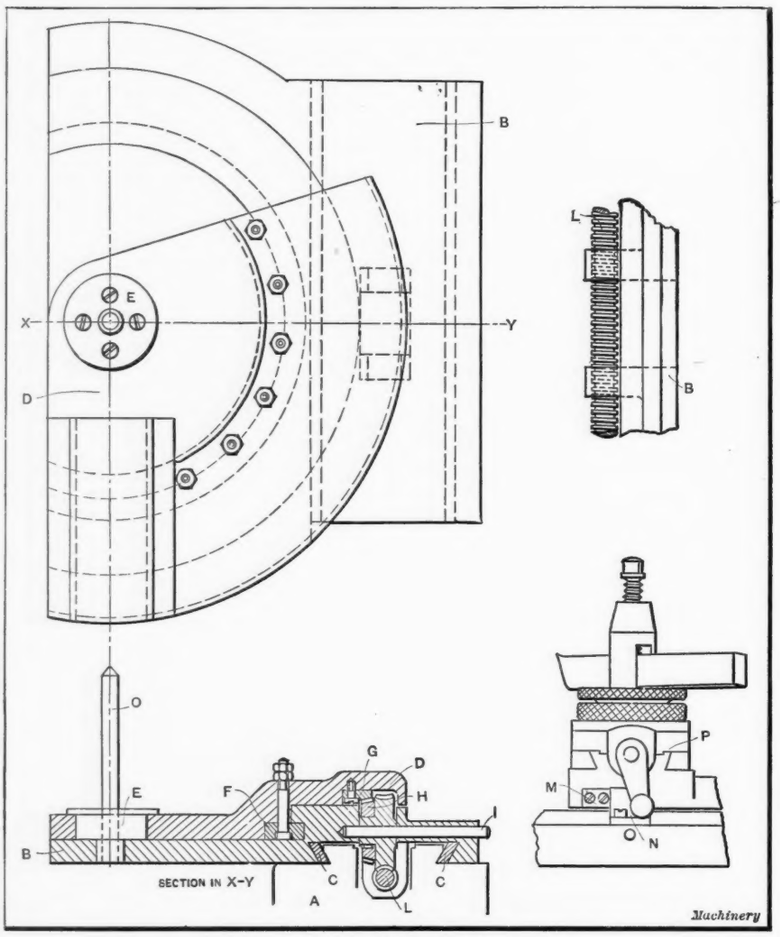


Fig. 2. Design of Spherical Turning Device

By moving the axis of the fixture in or out from the axis of the lathe spindle, circular surfaces such as rims of hand-wheels, faces of worm-wheel blanks, and similar work, can be turned. Work turned by this fixture can be finished in the same time as would be required for plain turning, and the design of several pieces has been modified so as to be turned by this fixture in order to obtain a more finished appearance.

Turin, Italy. C. BOELLA

OBSERVATIONS ON GEARING

In the April number of MACHINERY Mr. F. D. Buffum alludes to the necessity of proportioning gear teeth not merely to resist the load stresses which tend to cause breakage, but also to provide against excessive wear under continuous loads. He also asks for information relative to steel gears which are continuously transmitting the loads allowed by the Lewis formula.

During the writer's experience in designing gear mechanisms as embodied in geared heads and feed motions, there has not been a single case where steel gears running together have proved successful at tooth velocities exceeding about 400 feet per minute. A few have given trouble at even a lower speed, although in these cases the holes were hardened, ground and lapped to prevent the wear of the shafts upon which they rotated, and the gears were running in oil. In many cases the material had been changed on account of unsuccessful results.

It may be of interest to relate how one failure was dealt with. The mechanism consisted of a cone of gears driven from a long pinion through an intermediate gear—the usual tumbler gear arrangement. The long pinion was of 0.50 carbon steel; the intermediate and cone gears of 0.30 carbon steel, and soft. The whole gear mechanism was splash lubricated and the workmanship was good. Trouble first arose from the rapid wear of the tumbler gear, the only gear in continuous service. This was replaced by a casehardened gear which quickly "chewed up" the long pinion which was integral with the shaft and, therefore, could not be easily hardened. The material of the tumbler gear was then changed to phosphor-bronze, but the steel gears now wore out the phosphor-bronze gear. The final solution lay in making the tumbler gear of malleable cast iron, the idea being to provide a material somewhat more durable than phosphor-bronze but not as hard as the casehardened gear. The greasy nature of malleable cast iron probably also influenced the result.

In ordinary cases—cast iron to cast iron, or dissimilar metals, splash lubricated—the theoretical width of the face of gears as required by the Lewis formula has sometimes been cut down as much as 30 per cent. In these cases the tooth stresses have been calculated from the power delivery capacity of the belt under high tension (80 pounds per inch of width) and not from the amount of power actually delivered, which would probably not exceed more than one-half of the belt capacity. In cases of a "jam," the stresses are not always as great as might be imagined, for the reason that the shafts yield torsionally to a considerable extent, and thus relieve the stresses which would otherwise be borne by the teeth.

As regards shaft center distances, the writer does not agree with the statement that a small increase over the theoretical distance is of any great importance. In certain experiments made by the writer in which two gears of different diameters were mounted in such a way that the center distance could be varied to test the comparative noise developed at different center distances, it was found that in the case of eight-pitch gears, a closing up of the center distance of about 0.005 inch

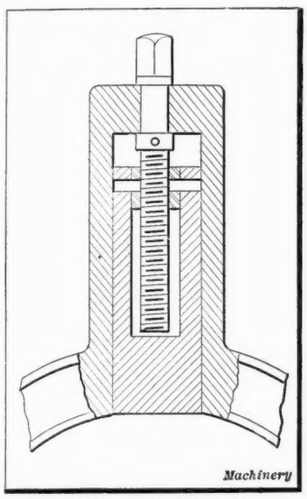
made no appreciable difference; beyond this point, owing to the jamming of the teeth, the noise increased considerably. Increases in the center distances above nominal up to about 0.125 inch also made no appreciable difference, but after this point the noise gradually increased up to the point of separation of the teeth. It is presumed that noise is a good index of the amount of wear. Backlash is of little importance if the load is continuous and not reversible.

As regards the comparative values of spur, bevel and worm-gearing, the writer would put spur gearing in the first place, unless the worm-gearing be so designed that the pressure angle is of maximum efficiency and the material the most suitable for the purpose. Either spur or worm-gear drives, however, are preferable to bevel gears. Difficulties in cutting accurate bevel gears, the unbalanced area of the tooth surface, the difficulties in setting to the correct pitch cones, all tend to prevent their successful application.

Didsbury, Manchester, England. FRANCIS W. SHAW

A LATHE STEADYREST OF UNCOMMON DESIGN

In the April number of MACHINERY, Mr. H. Terhune describes a steadyrest which the writer thinks impracticable. The writer does not understand the method of obtaining the chamber or body size hole in the jaw, or the method of assembling the screw with the top of the rest. The design is also rather expensive. The accompanying engraving shows a design which would entail the least expense, although even this construction should be used sparingly, as it will be found quite expensive.



Improved Design of Lathe Steadyrest

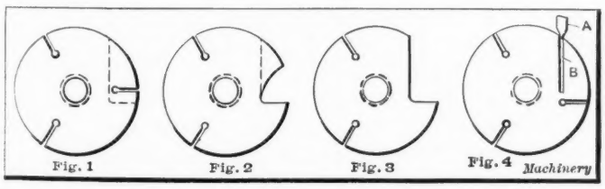
Dexter, Me. E. W. TATE

[Without entering into any discussion of the relative merits of the designs presented, it is safe to say that lathe manufacturers could undoubtedly afford to give more consideration to the design of steadyrests, even if the cost should be increased thereby. The steadyrest constitutes an important part of the lathe equipment, and if its efficiency can be increased, the comparatively slight increase in cost should not be begrudged.—EDITOR.]

TO FACILITATE THE GRINDING OF FORMING TOOLS

Figs. 1, 2 and 3 illustrate the methods which are most commonly used for making circular form tools. The saw cuts in the form tool, Fig. 1, are intended to relieve the strains due to hardening. Before this cutter can be used, however, the portion indicated by the dotted lines must be ground off. The method described by the writer in the following is intended to facilitate this operation.

The formed surface of a circular tool must be polished to remove the scale if good results are desired. For this reason most form tools are made as shown in Fig. 1, and after the cutter is hardened and polished, a cut, as shown in Fig. 2, is ground into the cutter, after which the cutter is ground as indicated by the dotted line to the appearance shown in Fig. 3. A wide tool made in this manner will require several hours for grinding in order to remove the metal without drawing the temper of the tool. On the other hand, if the tool was originally milled before hardening, as shown in Fig. 3, it would be almost impossible to polish the tool after hardening.

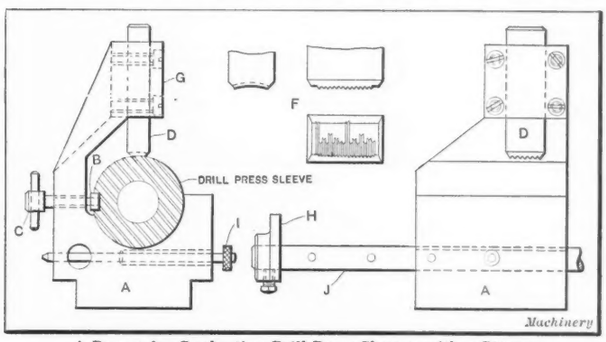


Figs. 1 to 4. Various Methods of Making Forming Tools

The simplest and most effective means for overcoming this difficulty is indicated in Fig. 4; this will save considerable expense in the making of circular form tools. The cutter is made with an extra slot, as shown, and after the tool is hardened and polished, the piece *B* is easily broken out, without injury to the cutter, by driving in a wedge as at *A*. The cutter may be held in a bench vise and only a slight tap of the hammer is necessary, after which the cut can be quickly finished off with an emery wheel. S. NEVIN BACON

GRADUATING DRILL PRESS SLEEVES WITH A STAMP

The accompanying illustration shows a device which was used satisfactorily for graduating a drill press sleeve with a stamp. The device consists mainly of a casting *A* which is machined out to fit the drill press sleeve. The sleeve has a spline in which the block *B* is held by the screw *C* for retaining the sleeve in the correct position. The stamp *D*, also shown enlarged at *F*, is made to graduate 1 inch, the graduations being 1/16 of an inch apart. The stamp *D* is held in a slot in the fixture by means of a cap *G* and screws as shown.



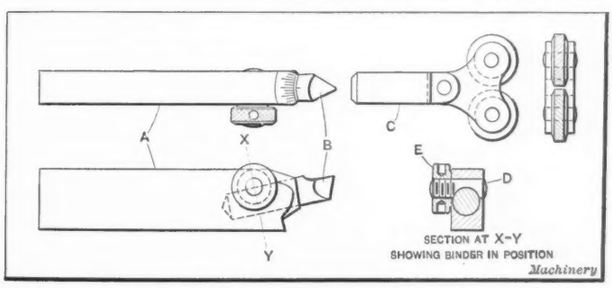
A Device for Graduating Drill Press Sleeves with a Stamp

In operation, the drill press sleeve is placed in the fixture and the end of it brought up against the stop *H*. The stamp is then given a blow with a hammer, after which the spring plunger *I* is pulled out allowing the rod *J* carrying the stop *H* to be shifted to the next hole. The spring plunger is now inserted, the stamp struck and the preceding operations continued until the sleeve is graduated to the desired distance.

J. S. B.

UNIVERSAL KNURLING AND TURNING TOOL HOLDER

The accompanying illustration shows a handy and useful knurling and turning tool holder, designed by a fellow workman for toolmakers' or mechanics' use and especially for those employed in experimental work. This device consists essentially of a holder *A* in which the turning tool *B* or knurling tool *C* can be held with the clamping screw *D* and clamping nut *E*. The turning tool is made from drill rod or from high-speed steel if preferred, and is cut off and ground to the required shape. It will be noticed that the hole in the front end of the holder is inclined at an angle

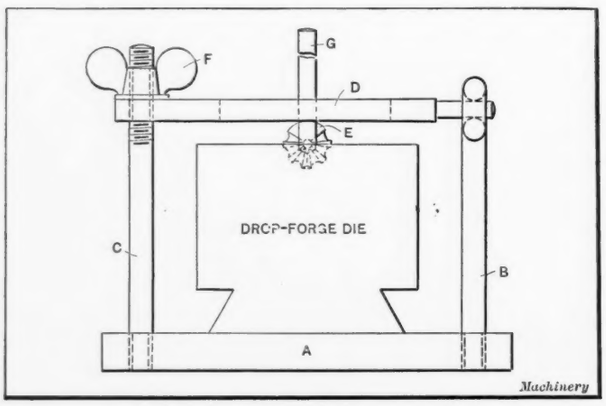


A Universal Knurling and Turning Tool Holder

with the base of the holder, the purpose of which is to obtain a positive rake on the turning tool for steel, etc. A holder containing a single roll knurl can be made and inclined in either direction at any angle with the axis of the work; for this purpose the front end of the holder is graduated in degrees, as shown in the illustration. The knurl-holder shown is supplied with two knurling rolls. C. F. S.

A CHERRYING FIXTURE FOR A DROP-FORGE DIE

The accompanying illustration shows a fixture which was designed for cherrying a hole in a drop-forge die. The hole to be produced is full at both ends, as indicated in the illustration, so that an ordinary milling cutter could not



A Cherrying Fixture for a Drop forge Die

be used for producing it. The hole to be cherried is first chipped out as near as possible to the required shape, care being taken to leave an equal amount of metal on both sides of the hole to prevent the cherry from "crawling."

The drop-forge die is placed on the bed *A* of the fixture, which is provided with two studs *B* and *C*, and a strap *D* is used for applying pressure to the cherry *E*. The stud *B* has an eye-bolt on its upper end, and the strap *D* is turned down to fit it. The bolt *C* is threaded to fit a wing-nut *F* which is used in connection with the strap for applying pressure to the cutter, the cherry being worked back and forth by means of the handle *G*. The cherry or cutter *E* is provided with teeth cut both right- and left-hand, starting from the central tooth. The handle *G* is driven into a hole drilled in the cherry. C. H. WILCOX

Springfield Mass.

BEATING THE SWEDISH GAGES

In relating the following incident, I ask the readers' indulgence for not giving names, as I fear that my reception at the works where the thing happened might not be as pleasing the next time I call, should I disclose too many of the true facts in the case.

Not long ago, a well-known company producing a very fine quality of machine work, got the improvement "bug" in its head and threw out some fair machinery in order to put in the very latest types. The result of this improvement proved quite satisfactory, and the quality of the product improved correspondingly. In showing the customers through the remodeled plant, much stress was placed upon the high-class workmanship obtained by the use of the new machines. All visitors were duly impressed with the fact that the shafts were right up to their correct diameters, that the holes were just right for running fits, that plane surfaces were spotted all over with contact spots, and that every piece interchanged with every other. The general manager was usually doing the showing around, and he did not look sorry to see the president loom up in the distance and join the group. Indeed the latter person was also duly impressed with what he was shown.

One day as the manager took a little group of visitors—prospective customers—through the plant, the climax was reached when he picked up some hardened and ground steel rings. He piled five or six on each other, in an absent-minded way, and was probably as much surprised as his visitors when he found that the surfaces were so perfect that he could lift the whole pile by the top ring. He instantly realized that this "beat the Swedish gages all hollow," and so he took full advantage of the situation, and puffed to a great extent.

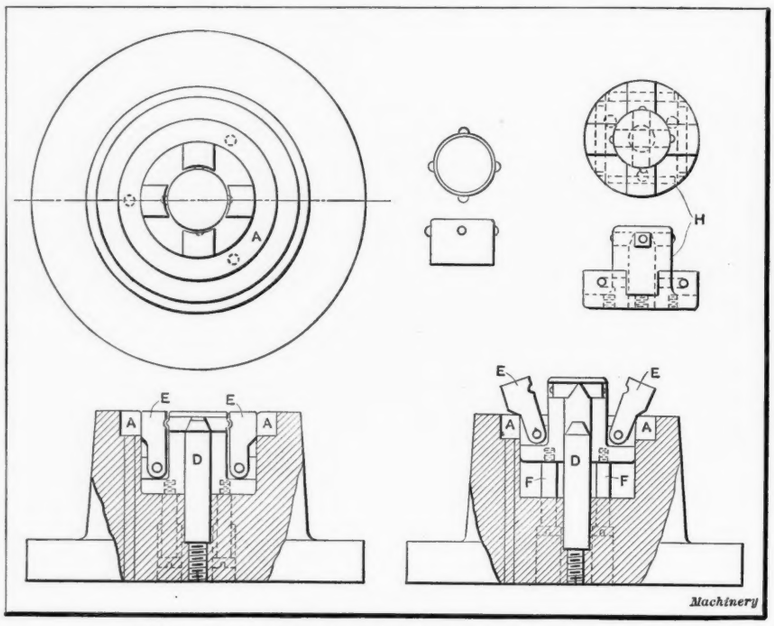
A few days later he started to show another visitor this fine work, talking loudly and impressively about it, but, lo! there was "nothing doing," for just the top ring remained in the manager's hand as he lifted it up, while the others were left "peacefully at rest" upon the bench. Evidently these rings were not as well ground as the previous lot, and he asked the grinder hand why they were not as carefully ground as the lot that were lying on the bench a couple of days ago. The grinder hand claimed that he had ground but one lot of rings, and that, undoubtedly, the rings now lying on the bench were the same as the ones that had been there a few days ago. There was an old hand around the shop, however, who had seen the manager grow up in it, and had never been able to get over calling him "Jimmy," and he offered the explanation: "Well, I nearly died laughing to see you showing up the fine work of the grinder to that crowd. It did look good, sure, but it was not the grinder but the magnetic chuck that should have had the praise for the job."

W. D. F.

TOOLS FOR RAISING LUGS ON SHELLS

The accompanying engraving shows a method for shaping half-spherical lugs on brass shells. The lugs were to be in an exact position in order to engage with grooves in a mating part. The method proved very successful and may be of interest to others.

A ring *A* is turned, hardened, and ground, and driven into a cast-iron bolster. The upper inside corner of the ring is well rounded. In the center of the device is provided a holder for the brass shells, this holder being shown in detail at *H*. Four square holes are provided in the upper part of the holder for the punches with half-spherical ends which form the lugs. The punches are a good sliding fit in these holes, and are tapered at the back end and expanded by means of plunger *D*, which is the shape of a truncated pyramid on the end. This piece is hardened and driven lightly



Method of Producing Half-spherical Lugs on Small Brass Shells

into the bolster, and adjusted by means of a screw from the bottom. The four jaws *E* are attached to the central holder and secured by a plain pin. They are hardened and polished on the outside. The central holder is a sliding fit in the bolster and is raised by means of three springs beneath it (not shown), the limit of the movement being governed by the screws *F*. The two positions of the jaws and punches shown indicate clearly the operation of the device. When the jaws are in the outward position, after the lugs have been formed, the shell may be removed. The removal of the shell pushes the small punches in flush with the holder, which is then ready for the next shell. Any plain, flat punch may be used in the press.

J. GALLIMORE

Meriden, Conn.

STANDARDIZATION OF GRINDER SPINDLES

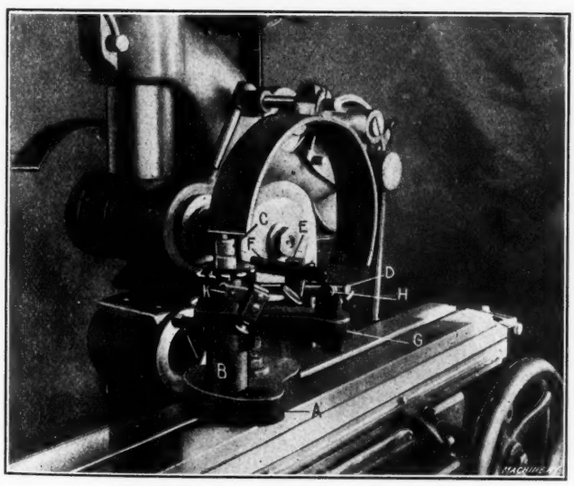
The other day the writer overheard a manufacturer saying: "If the grinder spindles only were alike, how much it would save." Quite a number of different makes of machines for rough and finish grinding were used in this shop. If both roughing and finishing grinding is to be done on the same machine, it is necessary to carry a full set of wheels for each machine. On account of the different sizes of the spindles, this requires quite a large investment in emery wheels and considerable storage room for the wheels as well. Standardization with respect to the grinder spindles, especially in the larger types of machines, would be of considerable value. The change may involve some trouble to the machine manufacturers, but, when the necessity is realized—in other words, when the buyers "holler" loud enough—this change will, undoubtedly, come about.

J. M. HENRY

New Britain, Conn.

A GRINDING ATTACHMENT

The grinding attachment shown in the accompanying illustration is intended for correcting errors in forming cutters caused by the hardening process. It is often said that when forming cutters are ground, they must not be indexed from the back of the tooth, because this does not give equal spacing. Now, we do not really care for equal spacing; what we want is to have all the teeth of the same length. In hardening, the cutter loses its shape, and the teeth become of different lengths,



Attachment for Grinding Form Milling Cutters

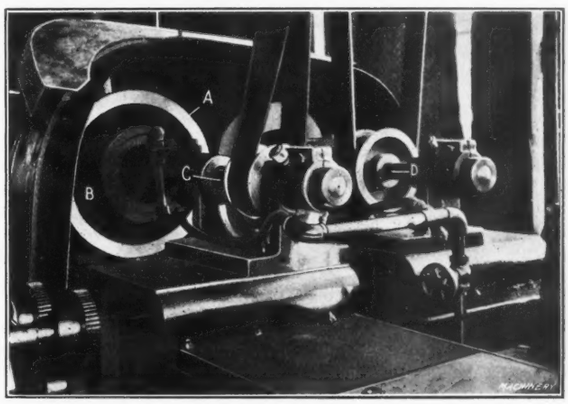
but the error can usually be easily corrected. On gear-cutting machines one tooth of the cutter often does all the work. The arbor is frequently blamed for this, but in most cases it would be found that one or more teeth are too long. These long teeth should be ground on the face until the teeth are all of equal length, as tested by an indicator, with the cutter on a mandrel between centers. This grinding will produce an uneven spacing, but it will produce a cutter where all the teeth will cut, and the cutter will remain in this condition, practically, until worn out.

The device shown in the illustration can be used on almost any cutter grinder. It takes but a short time to set up and gives satisfaction. The construction of the device, which might be varied to suit individual conditions, is apparent from the illustration. It consists principally of a base *A* to which is fitted an upright stud *B*, turned down at its upper end *C* to take the cutter. On the stud is also mounted a collar having an arm *D*. To this arm is clamped a bracket *E* into which is inserted the spring *F* which acts as a stop against the back of the tooth. The arm *G* is fastened by a set-screw to upright stud *B*, and, by means of adjusting screw *H*, the arm *D* with spring *F* can be slightly adjusted, relative to the fixed parts of the device, so that the cutter tooth can be gradually fed in towards the grinding wheel. A gage *K* is clamped to the device in such a manner that it will just touch the top of the tooth when this is of correct length, and by means of this the length of the teeth can be accurately measured. The whole device is simple, but it is possible, by means of it, to grind each tooth independently of the rest, gaging each in turn to make sure that they are all of correct length.

Nashua, N. H. CHARLES E. JACOBS

SIMULTANEOUSLY GRINDING INTERIORS AND EXTERIORS OF RINGS

In building the Dayton swaging machine, the Excelsior Needle Co., Torrington, Conn., grinds all hardened parts that are to serve as bearing surfaces in connection with the operation of the machine. The machine shown in the accompanying



Method of Grinding Interior and Exterior of Swaging Machine Rings Simultaneously

engraving was improvised to grind the interior and exterior of the steel ring that is forced into the head of the swaging machine. It is essential that the interior and exterior of the ring be true with each other; therefore, both of these surfaces are ground at one setting of the work. The ring, shown at *A*, is soldered to the special faceplate *B*. The wheel for grinding the interior of the ring is mounted on spindle *C*, while the wheel for the external grinding is mounted on spindle *D*. These spindles are mounted upon carriages on the same cross-slide and are driven in the usual manner. Provision is made for cooling the work at each of the cutting points. The method has proved very satisfactory.

C. L. L.

TAPS AND THEIR WORK

Though many of the questions in connection with taps and their work have been decided, and admit of no discussion, some points still remain on which a diversity of opinion exists. These should be rapidly reduced in number when investigators are not only willing to build testing machinery and carry on expensive tests, but freely give the world the benefit of the results of these investigations. The article on "Taps and Tapping" which appeared in the April, 1912, number of MACHINERY reflects credit on the investigators, but the writer would like some further information.

If but fourteen taps were used in obtaining the data presented in Table I, it is not at all surprising that the amount of power consumed increased rapidly after tapping the two crucible tool-steel nuts. It will be seen that the second nut of this metal required more power than the first in more than half of the fourteen cases. In other words, the taps dulled

rapidly. The same holds true in the case of the phosphor-bronze nuts. Hence, it seems that the comparison between the power consumed in tapping hexagon drawn brass and that consumed in tapping phosphor-bronze is scarcely a fair one, as the tap gradually becomes dull. While it may be said that tapping ten nuts need not make much difference with a tap, the figures given show an average increase of power consumed by the second nut tapped in each kind of metal.

It is interesting to note the reduced amount of power consumed by tap No. 10 in tapping its second nut in both the third and fourth metals tapped, and the increase of 65 per cent in the case of the second phosphor-bronze nut. The hexagon screw stock seems to require less power for tapping in the case of the second nut, but for steel the average is slightly greater for the second nut. From these irregular results it would seem that such experiments should include scores of taps and hundreds of nuts, in order to reduce the effect of such amounts of power as are consumed by taps Nos. 8 and 10.

The fact that decreasing the diameter of the hole to be tapped by a ½-inch tap from 0.425 to 0.400 inch increases the amount of power consumed about 100 per cent, is not surprising, as the amount of metal removed is, thereby, also increased nearly 100 per cent, and the chance of clogging the flutes is very much greater, as we have less room in which to take care of nearly double the amount of chips.

Could not someone who has the facilities for carrying on tests of this kind also let us know the amount of power consumed in removing the metal from a thread groove under conditions as similar as possible to tapping, but with the wedge and chip-choking elements eliminated? Comparison between the amount of power consumed in tapping and in cutting threads externally would also be interesting. Has not the large amount of tool surface in contact with the work and the ever-present tendency to wedge a great deal to do with the amount of power consumed by the taps?

As a cutting tool a non-relieved tap is not an inviting proposition, but when a tap must be reversed a relieved land is supposed to gather small chips and thus dull and even break the teeth. Most tap makers avoid the tendency to wedge by making their taps slightly "reverse" taper. A reverse taper tap cannot do perfect work, but the very slight inaccuracy of thread angle caused by the reverse taper used is in most cases negligible. Reverse taper taps, however, consume much less power than parallel taps.

Hamilton, Ohio. W. S. ROWELL

[With regard to the methods of making the tests recorded in Table I, in the article on "Taps and Tapping" in the April number, we are informed by the test department of the Wells Bros. Co., Greenfield, Mass., that the figures in the chart "represent the average variation of a number of tests of each material. In making these tests different sequences were used (with regard to the different materials tapped), so that the tests would be absolutely fair to each material."—EDITOR.]

OVERHANG IN MACHINE DESIGN

In the March number of MACHINERY, "Onlooker" quotes, "Overhanging is a vital error in design," and adds, "Mechanical designers are beginning to recognize this fact to a marked degree." Assuming that by "overhang" is meant the condition of a part similar to a cantilever and that a "vital error" means an absolute mistake, the writer takes exception to these statements, and will attempt to show that the former is not a practical proposition so far as design of machinery is concerned.

It is obvious that there are many types of machines impossible to design so that they will fulfill the object for which they are intended, without overhang. A radial drill, for example, of the general kind, must necessarily have an arm that can be quickly and easily swung from one position to another. If an outer stay is provided, the machine becomes restricted in its capacity. Such stays are often supplied as temporary attachments, but it is often impossible to apply them when the heaviest duty is required from the machine. Hence, the arm is made strong enough to safely withstand the strain imposed upon it by the work performed without the use of the stay.

Some English makers have eliminated the overhang of the drill spindle from the arm by designing what is called a "central thrust" arm. Thus the torsion is eliminated, but the deflection of the arm upward, with relation to the column, is not affected thereby. The deflection due to three inches of overhang is eliminated, but that due to, say, forty-two inches remains unaltered. In a well designed machine without the central thrust arm, the torsional deflection is not appreciable, even under maximum duty, so that this attempt to avoid overhang is of little practical value, as it is often obtained at a sacrifice in handiness of operation.

The shaper offers another example of a machine where overhang is unavoidable. For a large class of work it is much more suitable than the planer, although in the latter the tool is carried on a beam supported at each end. (The uprights, by the way, which carry this beam, are "overhung" from the bed, so that even the planer does not answer the requirements for a good comparison.) It is not practicable to use some kind of a support for the outer end of the shaper ram, as the usefulness of the machine would then be greatly reduced. Some makers, however, place a support under the table so as to minimize the effect of the overhang. The advantage gained by so doing may be more apparent than real, for with a given pressure between the tool and the work, the sliding ram is deflected to a greater extent than when the table is not supported; yet, this support may be useful when very heavy work is secured to the table. Notable cases of overhang are also met with in gear teeth, most cutting tools, lathe spindles, tailstock spindles, etc.

The objection to overhang is, of course, deflection under load, but this is not avoided if a beam supported at its ends is substituted for a cantilever. Under similar conditions of length and section it is reduced, but the difference is one of degree, not of kind. The writer does not, of course, advocate overhang when it can be advantageously avoided, but he realizes that conditions exist which call for a compromise, and he does not agree to the statement that "overhang is a vital error in design," and does not believe that it should be accepted without some qualification. JOSEPH JEWSBURY

Birmingham, England.

[While somewhat erroneously expressed, it is, of course, clear that "Onlooker" did not intend to convey the idea that overhang was never permissible in machine design. Read in connection with the paragraph in which the expression occurred, it is reasonably clear that the idea in "Onlooker's" mind was that overhang was a serious error in all cases where there was no need for it—where ample support underneath or near the end of a cutting tool, for example, was possible. Undoubtedly, "Onlooker" did not intend to be taken quite so literally as our correspondent has understood him.—EDITOR.]

HEATING HIGH-SPEED STEEL IN A BLACKSMITH'S FORGE FOR HARDENING

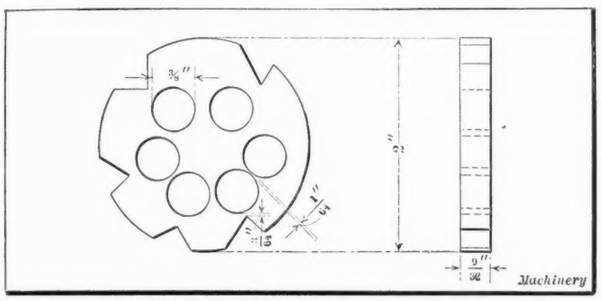
Various receipts and methods have been given for hardening high-speed steel, but the factor which renders most of these methods unsuitable for the "backwoods" mechanic is that they require conveniences not often found in a small shop. The heating appliances usually consist of a pail of water and a blacksmith's forge. With these facilities one is expected to perform any operation of heat treatment from the welding of a broken crankshaft to the hardening of a "circle tool."

Not long ago the writer was employed in a small shop as foreman, and having difficulty in getting the high-speed cutters through the hardening process satisfactorily, he investigated the methods used. The trouble seemed to be that the cutters came out either without good "red hardness," which constitutes the peculiar value of such steels, or else though hard, they would be blistered and the corners so rounded that they were spoiled. Occasionally the tools would be both soft and blistered. Inquiry revealed the fact that the soft but unspoiled cutters were heated in a gas muffle furnace which had been installed for hardening punches and dies,

while those rendered unfit for use by scaling were hardened in a blacksmith's forge with soft coal and plenty of blast.

As it was a rather hopeless task to change the gas outfit so that it would produce the required heat for high-speed steel, some experimenting was done with the forge fire, and it was finally discovered that if the work was covered with a thin coating of fire clay and salt, and further protected by a thin shield of sheet metal, it could be subjected to a coal fire. After being brought to the required heat, the tool was cooled in a tank of kerosene without removing the shield.

The accompanying illustration gives the dimensions of a piece that was hardened in this manner. The holes were drilled and then reamed with a 3/8-inch reamer, and all of the sharp corners were milled. Some idea of the lack of scaling or warping may be obtained from the statement that after the dirt was cleaned out of the holes, the shank of the same reamer could be put through. The burrs caused by milling and reaming were still as sharp and pronounced as before heating. The wall between two of the 3/8-inch holes was only 1/64 inch thick, and the wall between the milled corner and one of the holes was 3-64 inch thick. No cracks developed, nor was there any noticeable warping at these



A Piece of Work heated for Hardening in an Ordinary Blacksmith's Forge, without Scaling or Warping

points. The condition of the sharp edges would warrant the belief, that, if it had been a cutting tool it would have been in a fit condition to use without sharpening.

As to the degree of hardness obtained, the writer kept the piece in the condition in which it came from the hardening bath—without tempering—and afterward had the opportunity to test it with the scleroscope; with this instrument a reading of 105 was obtained. This reading compares very favorably with that obtained with the best grade of carbon steel hardened in a satisfactory manner. The piece illustrated is made from Bohler's rapid Styrian steel (high-speed). Judging from various other experiments which were tried, the writer has come to the conclusion that the prime necessity in hardening high-speed steel is to have plenty of heat, and to provide shields for the work to prevent the scaling which is due to exposure to the atmosphere when the tool is at the temperature for hardening. It does not especially matter when using the shield, whether the work is heated in a muffle, a barium chloride bath, or some home-made affair like that previously mentioned. With proper care excellent results may be obtained, even with that old standby, the blacksmith's forge.

F. A. Parsons

Milwaukee, Wis.

BURNISHED THREADING DIES

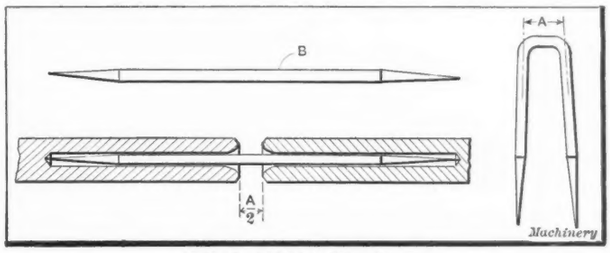
Threading dies of the button or spring types will last much longer and produce superior threads if the threads in the dies are burnished after cutting, and also after hardening, than if left unburnished as they ordinarily are. The burnishing is accomplished with a threaded master plug, which is hardened and lapped, but not fluted. This threaded plug is run through the die, which is left from 0.001 to 0.0015 inch small when the thread is cut. Lard oil is used as the lubricant. After the die has been hardened and tempered, the threaded plug is run through again.

Another advantage gained by putting the plug through the die after hardening, is that the lead of the threads, which is distorted in the hardening process, is corrected. A die made in this manner will cut clean and smooth, and will stand up much better than a die that has not been burnished because the material about the threads is compressed by the burnishing plug and all the burrs are removed.

D. T. H.

DEVICE FOR MAKING STAPLES

The accompanying engraving shows a simple device for making staples of the type shown to the right. The method is as follows: Cut off the wire to the proper length and point it as indicated at *B*. The device for bending consists of two pieces of steel rod, slightly less in diameter than the width *A* from center to center of the staple legs. Drill a hole in the end of each of these two pieces. The hole should be slightly larger than the diameter of the wire, and the depth of the



Method of Making Wire Staples

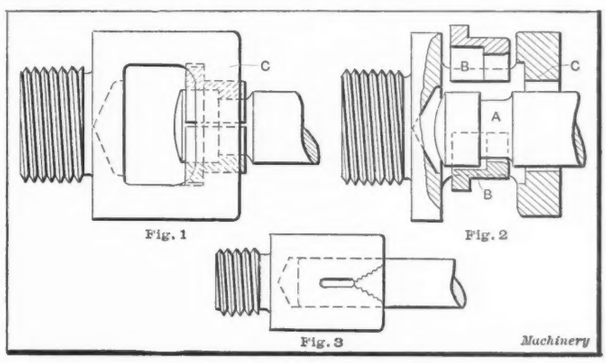
hole should be about one-half the length of the wire less one-quarter of the distance *A*. The holes should be slightly chamfered, or bell-mouthed, and the corners should be slightly beveled, as shown. When the wire is placed in these handles, they are forced together to a parallel position. The beveled corners come together and act as a fulcrum and a smooth, even bend results.

C. M. S.

IMPROVED FORM OF PULL-BUSH FOR BROACHES

The broach used with the "La Pointe" broaching machine is usually secured to the pull-bush by means of a cotter passing through the bush and broach. This connection frequently fails, the pull-bush giving way as shown in Fig. 3; or worse still, the end of the broach gives way. The trouble can be overcome by using a pull-bush of the type shown in Figs. 1 and 2.

The end of the broach is reduced in diameter as shown at *A*, leaving a shoulder; half-bushes are turned to suit the bore of the pull-bush *C*, and bored as shown at *B* to freely fit the end of the broach. The pull-bush has a slotted hole, wide enough for the insertion of these split bushes.



Improved Design of Pull-bush for Broaches

In use, the broach end is inserted through the hole in the pull-bush, the half bushes are placed on the neck, and are then drawn back into the hole as shown in Fig. 1. By making the bore large enough when designing a pull-bush of this description, it is quite a simple matter to arrange for one bush to cover a large range of broaches, and in each case retain the greatest possible strength in the broach. Split bushes are made to suit each size of broach. This cannot be done when using a cotter, and therefore the connection is cheaper to make. The half-bushes are easily made as compared with the cutting of the slots for the cotters, and it is advisable to make them so that if anything gives way, it shall be these parts. A little care in determining the width of the shoulders in these split bushes will allow for this tak-

ing place before either the main pull-bush or the broach end can give way. G. R.

SOLVING OBLIQUE-ANGLED TRIANGLES

The writer wishes to add a few words in reply to the inquiry of O. E. H. in the How and Why columns of the February number of MACHINERY. When two sides (a and b) and the included angle (C) are given, the third side (c) can be found directly from the formula:

$$c = \sqrt{a^2 + b^2 - 2\,a\,b\cos C}$$

This formula is not very convenient to use except when a and b are numbers easily squared; however, this is generally not the case. By using the formulas:

$$\sin x = \frac{2\cos\frac{1}{2}C}{a+b}\sqrt{a\,b}$$

and

$$c = (a+b)\cos x$$

the computation will be much facilitated, especially when using logarithms. By using functions of the half angle we also obtain greater accuracy and avoid the difficulties met with when using negative values. WM. W. JOHNSON

Cleveland, O.

ATTACHMENT USED FOR GANG PUNCHING

When it is desired to use a gang punch on the ordinary punching and shearing machine and the positions of the holes are such that some of them are a considerable distance outside of the lower face of the crosshead, it is not practicable to use ordinary punch and die blocks. Punching of this kind, however, can be easily done by means of an attachment such as shown in Fig. 1, which represents a side view of an ordinary punching and shearing machine equipped with punch and die blocks for gang punching. The punch block A is attached to the crosshead by means of links as indicated, while the die block B is fastened to the bed plate by any ordinary means. The punch and die blocks are connected by a hinge at C; D is the stripper and E one of the two braces supporting the front of the stripper.

In Fig. 2 is shown a front view of the punch block illustrating the manner of connecting it with the crosshead. The wearing plate F, shown in this illustration, is attached to the crosshead and bears against the punch block. In Fig. 3 is shown a perspective view of the die block giving a clear idea of its construction, the stripper being removed in this illustration. No attempt has been made to show the means of securing the punches and dies in their respective blocks, or the provisions made for getting rid of the punchings. This latter may be accomplished, for the central dies, by drilling holes at an angle from the bottom of the die to enter the opening usually provided in the center of the bed plate, and for the others by holes so drilled that the punchings are discharged at the front, back or on the sides of the bed plate.

This device has been used for punching plates about 3/16 inch thick, of high-carbon steel, which is difficult to punch. If thicker plate is to be punched, the distance back to the hinge or fulcrum C must be proportionately increased in order to give as nearly a perpendicular motion to the punch as possible. The parts are hinged together sufficiently rigid so that the punches strike the plates squarely over the holes in the dies. It would seem, at first sight, as if there would be enough of a bending action on the punches to easily break them off, but this is not the case, providing, of course, that the fulcrum C is placed at a suitable distance away from the center of the crosshead. W. L. B.

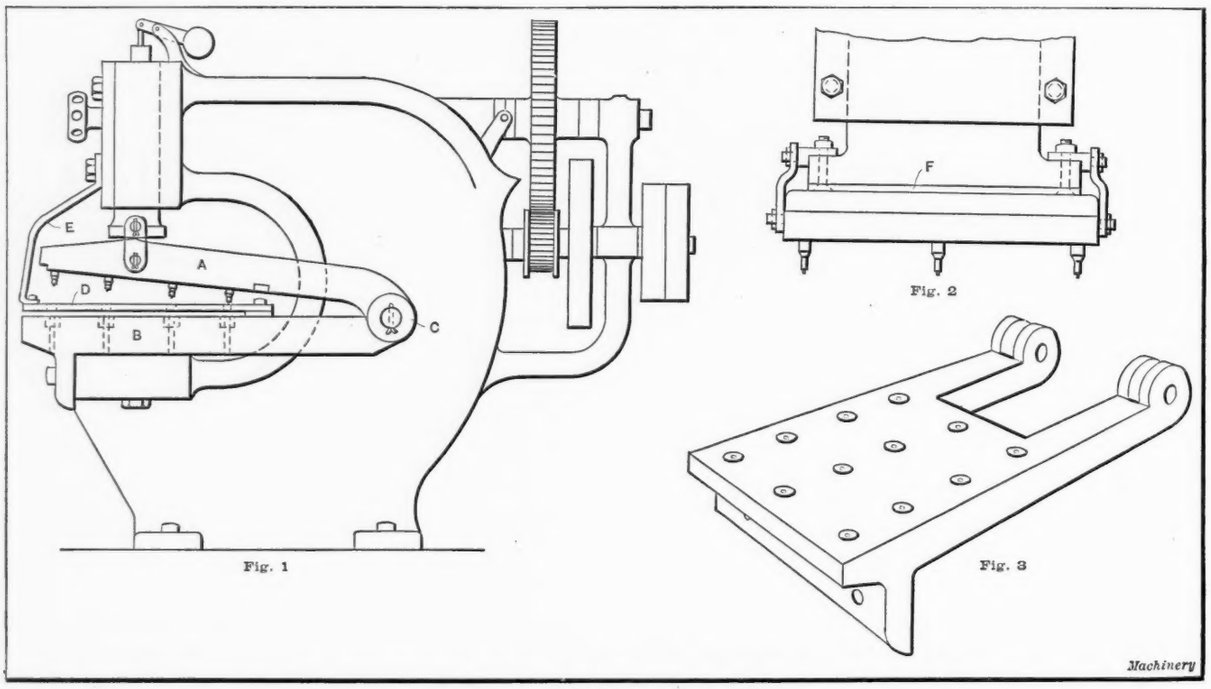


Fig. 1

Fig. 2

Fig. 3

Figs. 1 to 3. Attachment for Gang Punching

SAVING A SHAFT BY KNURLING

Referring to the article, "Saving a Shaft by Knurling," in the April number of MACHINERY, the writer would like to say a few words. It would seem that a straight knurl would be best for this purpose—one that makes parallel, longitudinal grooves and ridges. It would seem that the spiral or cross-cut knurl would hardly be practicable to use. The best results are obtained when the size is increased only enough to make it possible to obtain a press fit, but it should be remembered that the bearing surface is reduced and, therefore, when an allowance of only 0.0005 to 0.0015 inch is required for a tight fit with a smooth surface, the knurling must increase the diameter from 0.002 to 0.003 inch, in order to produce just as good a fit. The ridges tend to cut into the sleeve, and if the assembled details are taken apart, the fit is none too good the second or third time.

Nevertheless, the method has its advantages. It is cheap, and the fitted part runs true, which it does not always do when some other methods for saving the work are resorted to. Although the writer has never seen the method tried for the purpose, he does not think that it would be suitable where an air- or liquid-tight joint is required, as the sleeve is generally considerably scored when the knurling is heavy.

Erie, Pa. A. N. HAMMOND

CASEHARDENING GEAR TEETH WITHOUT DISTORTION

In the May number of MACHINERY a brief item is published on the casehardening of gear teeth without distortion. The writer wishes to make some friendly criticisms on the methods there set forth. It is stated that the gears are copper-plated all over before taking a finishing cut on the teeth. The finishing cut removes the copper plate from the tooth faces and flanks, and when casehardened, these parts only become hard, the carbonizing effect of the pack being prevented on the other parts of the gear by the copper-plate. The practical result is casehardened teeth with so little distortion of the gear as a whole that it can be corrected to practically perfect accuracy by means well-known to gear makers. The well-known means alluded to are, presumably, "setting" under the press, or similar means. This, in the writer's opinion, is very bad practice, as the means used to correct the gear sets up internal strains, which are retained in the gear. Should the gear at any time receive a sudden shock, it may upset the molecular structure of the steel, and so relieve the strains. One often wonders why gears when first placed in a car appear fairly quiet, and then, while on test, suddenly become noisy, and finally have to be replaced—a procedure which has often come to the writer's notice. A great deal of noise and hammering can be traced to "setting" under the press. To overcome the trouble already stated, it should be strongly advised to leave metal for supporting the gear while undergoing heat-treatment and to take a cut all over after carbonizing except on the tooth faces and flanks. Then only these latter parts will harden.

Finally, after hardening, the gear should be located true with the teeth, ignoring all other parts, and then the surplus metal left for supporting the gear should be removed, at the same time truing it up with the teeth. This, obviously, does away with the necessity of "setting" the gear under the press.

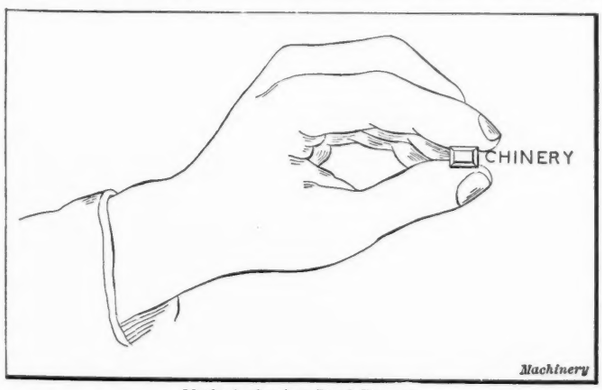
The writer does not want anyone to think that he is in any way condemning copper-plating for preventing parts from casehardening. He has seen this method in use for bicycle bottom bracket axles some ten years ago. The axles were copper-plated all over and then the plating was removed from the ball races only. It is also good practice to copper-plate the threads on the ends of hardened shafts and the like.

Anyone who wishes for further information upon the matter should refer to the article, by the writer, in another part of this issue entitled "Processes in Production of Automobile Transmission Gears."

Birmingham, England W. BETTERTON

USING STEEL STAMPING LETTERS

The "Remarks by the Onlooker," in the February number of MACHINERY, relating to the way the average machinist uses steel stamping letters, prompts the writer to describe



Method of using Steel Stamps

a method which he has used successfully. Others who have been told about it have found this method equally good, and it is, therefore, submitted with the hope that it will prove useful to someone.

The accompanying engraving shows fully as well as a description the principle of the method. The words are stamped backwards, beginning with the last letter. By doing so, it is possible to see exactly what one is about. The hand does not cover up the letters already stamped. A guide line should be scribed for the figures, so that they will line up properly.

In addition, attention should be called to the fact that cast iron should not be stamped without first chipping off the hard skin. To do so will improve the appearance of the stamping and will considerably lengthen the life of the steel stamps. A nick should be filed across the upper side of the type so that one can see or feel instantly when the right side is up. In this way, stamping of the letters upside down is avoided.

Christchurch, New Zealand. PERCY FRAMPTON

SEASONING CAST IRON FOR MACHINES

Having noticed the request for suggestions from readers as to ways and means of cheaply accelerating the seasoning process, the writer offers the following:

First, under the title "The Mobility of Molecules of Cast Iron," (a contribution to a discussion of the physics of cast iron), a resumé of some protracted investigations of this subject may be found in the transactions of the American Institute of Mining Engineers, 1896 (Vol. xxvi, beginning page 176).

Second, it was shown therein that release of cooling strains in iron castings may be very greatly accelerated—without heat annealing—by subjecting such castings to repeated shocks or vibrations while cold. In the case of ordinary test bars of one inch square section, broken transversely, with supports twelve inches apart, there was a gain in strength of bars subjected to shocks in a tumbling barrel for one hour of about twenty per cent, as compared with companion bars of the same size cast from the same ladle, not so treated.

Third, in a report of the committee of Science and Arts of the Franklin Institute on this discovery, entitled "The Molecular Changes in Cast Iron Caused by Vibration," dated May 5, 1897, and printed in the *Journal of the Franklin Institute* July, 1898, a maximum increase in load of 42 per cent and increase in deflection of 55 per cent is shown in a table giving tests of 166 bars, 26 by 2 by 1 inch tested flat, twenty-four inches between supports 83 of which were subjected to shocks as compared with untreated companion bars.

Fourth, the release of cooling strains in castings by shocks without aid of heat having been fully established by these and numerous similar and independent tests, the American Society for Testing Materials inserted a clause in its revised specifications for iron castings to the effect that test bars must not be subjected to shocks or vibrations prior to testing.

Fifth, the most effective and thorough method of removing internal stresses in iron castings "to prevent warping after finishing" is the old one of annealing by heat to cherry-red before machining, but this is impracticable in many cases, and careful tests have shown that an analogous effect may be produced by subjecting the castings while cold to rapid vibrations or shocks, thus accelerating the removal of internal stresses by molecular movement.

Sixth, finally it may be accepted as a fact that all iron castings improve with age, owing to the slow or gradual escape of cooling stresses due to rearrangement of molecules.

Philadelphia, Pa. ALEX E. OUTERBRIDGE, JR.
Metallurgist with William Sellers & Co., Inc.

A CUTTING LUBRICANT FOR COPPER

Copper, as most mechanics know, is very difficult to work with the ordinary steel tools, but if the following method is used good results will be obtained. Grind the tool as for cutting steel, giving it as much top and side rake as possible. The most important point is to have the tool well oil-stoned, not along the cutting edge but on the top, as the cutting edge must be kept clear of chips at all times. For a lubricant, use sweet cow's milk. This may seem strange, but it has proved to be about the only lubricant that will produce a surface on copper as smooth as glass.

Milwaukee, Wis. FRED FRUHNER

HOW AND WHY

DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST

Give details in full and name and address. The name and address will not be published with the answer.

STANDARD PITCH FOR PIPE

W. K.—Why was 11½ pitch selected as the standard for pipe 1 to 2 inches in diameter? It is inconvenient to gear up for in the lathe, requiring a special change gear. Why would not 12-pitch have answered exactly as well?

A.—Twelve pitch would have been exactly as good as 11½ pitch and is sometimes used when gearing is not available for the standard. For the reason why 11½ pitch was adopted, we refer you to the readers of MACHINERY. If anyone can offer a reasonable explanation, we shall be glad to hear from them.

CAST-IRON PACKING RINGS

L. H.—Why is cast iron so generally employed for piston rings? Has it proved superior to other metals for the purpose? I have searched through several books on machine design without finding the desired information.

A.—Cast-iron packing rings are almost universally used in the pistons of small reciprocating engines and generally in the largest ones. The reasons are that cast iron is low priced; it can be cast in hollow cylinders suitable for making rings and requiring a minimum of machine work; it is close grained, tough and elastic, in suitable mixtures; it wears quickly to a mirror-like surface when working in contact with the wall of a cast-iron cylinder, being an exception to the rule that like metals do not wear well together; it is available wherever ordinary castings are made; and it is easily turned, bored and faced on the lathe. Steel, on the other hand, is higher priced; it must be forged and welded into rings, unless special machinery is available for rolling the rings up to shape; it must contain sufficient carbon to give it temper, if the rings are to be as elastic as cast iron; it wears quickly, working in contact with cast iron, and wears the cast iron rapidly also; and it is harder to machine than cast iron. Some of the bronzes make excellent packings for steam engine pistons, but they are costly and not readily obtainable. The principal objection to cast iron is that the rings are likely to break under shock; in some situations steel must be used because of this defect, especially in steam hammers.

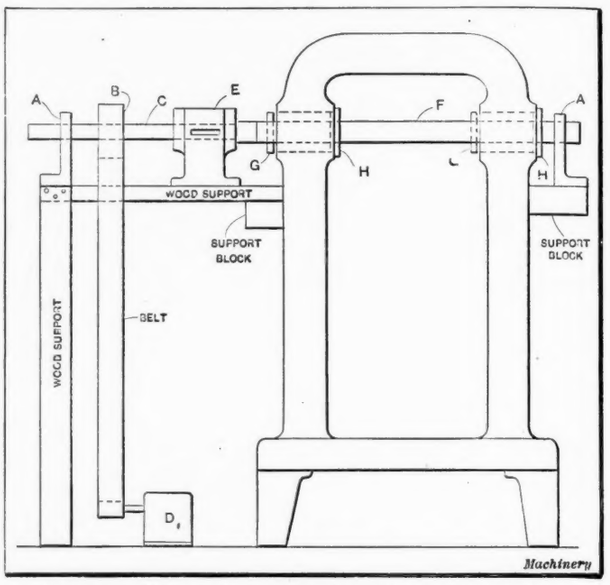
STRAIGHTENING DRILL ROD

D. A. H.—The writer would like to have proposed a method for straightening drill rod 0.105 inch in diameter, furnished in 24-inch lengths. The accuracy must be such that when the rod is rolled on a flat surface no part will be more than 0.005 inch out of true. Also, a method is required for giving a spring temper to these rods and yet have them remain straight. The writer has had to straighten many thousand pieces of untempered commercial rods, as well as a large number of spring tempered rods, and has come to the conclusion that there is no royal road to success in this respect. It seems that this is too close work for wire straightening machines, and, of all the methods tried, none approaches hand straightening. An intelligent helper after careful instruction and some practice has been found to be able to straighten fifteen to thirty rods per hour of unhardened, and ten to twenty of hardened rods, depending on the hardness of the stock, the number of short kinks, etc. The method used has been to mount a hard cast-iron surface on a bench, placing it about on the level with a man's eyes when seated. When the rod is laid on this surface the high spots show the light under them and are straightened by a blow from a 4 ounce hammer. When spring tempered rods are wanted, however, the difficulties are greater, and every rod has to be straightened after hardening. The writer learned from a steel salesman that "our steel can be hardened straight very easily; all you have to do is to heat it uniformly and dip it in water, end first." Marvelously simple until you try to do it! It is possible that someone has had similar work to do and has been more successful than the writer. If anyone has accomplished this work in a more satisfactory manner than outlined above, his experience would prove valuable and interesting.

PORTABLE BORING-BAR

Answered by William N. John, Milwaukee, Wis.

In the How and Why columns of the May number of MACHINERY, J. H. asks for a suggestion for methods to be used for reboring punch and stamping press journals. A couple of months ago we had occasion to rebore the 6-inch bearings in a No. 75½ Bliss power press. We made use of the rigging shown in the accompanying engraving. A scaffold was first erected of 3- by 10-inch planks. Then the saddle or sliding head and spindle were removed from a 24-inch back-geared drill press, the spindle being used to drive the boring-bar. On the scaffolding we also attached the lathe steadyrests from a 16-inch lathe to support the ends of the spindle and bar. On the spindle a 12-inch pulley was fastened with a feather key, this pulley being driven with a 3-inch belt from a 2½-inch pulley on a ¾ horsepower motor fastened to the floor. The boring-bar consisted of a piece of cold-rolled steel about one-half the diameter of the journal. The first cut with the boring-bar enlarged the hole about 1/16 inch. The



Diagrammatical View of Arrangement used for Reboring Bearings in a Stamping Press

cut was reduced each time the boring-bar was run through the journals, until a smooth bore was obtained; about 1/16 inch was planed off from the caps.

In the illustration *A* are the steadyrests; *B*, the 12-inch pulley; *C*, the drill press spindle; *D* the motor; *E*, the sliding head; *F*, the boring-bar; *G*, the boring-bar cutters; and *H*, plates having holes which are lined up with the old bore and which support the boring-bar. The illustration simply shows the arrangement in a diagrammatical way.

The work on this rigging was begun when the plant was shut down Saturday, and the punch press was ready for work Monday morning.

* * *

MACHINE TOOL EXHIBITION AT OLYMPIA, LONDON

The Machine Tool and Engineering Association, Ltd., of Great Britain has organized a machinery exhibition covering principally machine tools, to be held from October 4 to 26, at Olympia, London. Nearly two hundred firms have signified their intention to take part in this exhibition so far, and a casual perusal of the list of exhibitors indicates that the exhibition will be of unusual interest to mechanical engineers and to machine tool builders and users. Not all of the exhibitors, of course, are engaged in machine tool manufacture, but a large portion are makers of either machine tools or accessories. A feature of the exhibition which will be of considerable interest, will be the application of the electric drive to a great many of the tools exhibited. The arrangement for safeguarding machines will also be of interest, as it is required by the committee that passes on machines and appliances to be exhibited that all machinery and tools must be properly guarded to meet with the requirements of the ordinances of the London County Council. Altogether, the exhibition will form an unusual opportunity for studying the present status and trend of the machine tool industry in Great Britain.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS
IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

THE DAVIS-BOURNONVILLE "OXYGRAPH"

The "oxygraph" is a recent development effected by the Davis-Bournonville Co., 97 West St., New York, for cutting steel by the oxy-acetylene process. It is constructed on the pantograph principle and is so arranged that steel of several inches thickness can be cut to any desired shape by simply guiding the pantograph arm, which is equipped with a cutting torch and a mechanically propelled tracer. When the steel is to be cut accurately to a given shape, a drawing is placed on the table of the machine, and, as the operator guides the tracer along the outline of the drawing, the cutting torch is given a corresponding movement on a reduced scale. In this way, intricate shapes can be cut with considerable rapidity.

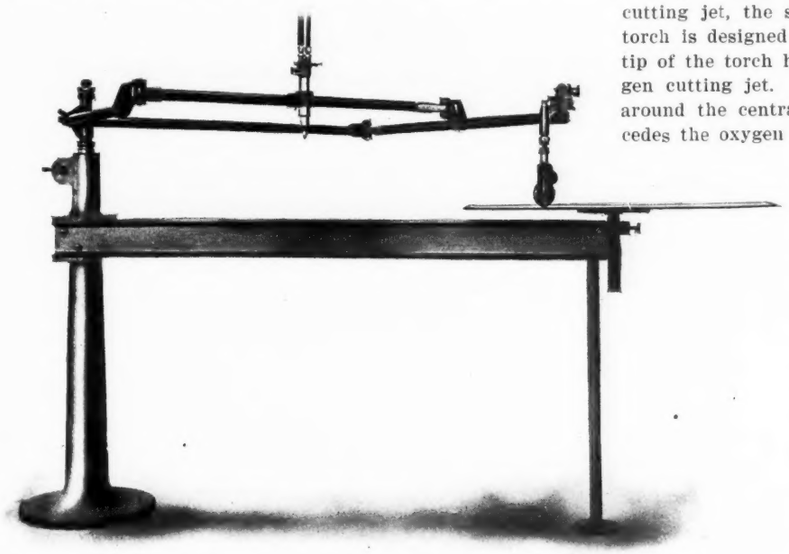


Fig. 1. The Oxygraph—A Machine for Cutting Steel by the Oxy-acetylene Flame

The oxygraph, which is shown in Fig. 1, is very simple, both as regards its construction and operation. It consists of a heavy cast-iron column and an outboard standard, upon which are mounted horizontal supports for holding the work. At the left end of the work-table, the pantograph arm is pivoted, and at the opposite end there is a steel table for holding the drawing corresponding to the outline of the form to be cut. The tracing wheel, which is a thin steel disk, is attached to the outer end of the pantograph arm and rests on the drawing-table. This wheel is positively rotated by a small motor attached to the end of the horizontal arm, and it can be swiveled about a vertical axis for moving in any required direction. This mechanical propulsion of the tracing wheel is a novel and valuable feature and has two decided advantages: In the first place, it provides a uniform predetermined speed for the cutting torch, so that the latter moves at the proper rate to obtain the greatest efficiency; and, in the second place, it is much easier for the operator to follow the lines on a drawing, because his entire attention can be given to the control of the tracing wheel, the latter simply being turned one way or the other, as may be required. The motor is connected with the tracing wheel through small gearing and shafts, and it is started or stopped by a switch conveniently located above the wheel. The motor is small and compact and requires very little power. It can be operated either by a small storage battery or a wire attached to an electric light fixture.

This machine will cut steel three inches thick at a speed of six inches per minute, and the company expects to increase this capacity considerably. It should be mentioned that the cutting is done with the oxy-acetylene flame and the oxygen cutting jet, the same as in ordinary practice, although the torch is designed especially for use with the oxygraph. The tip of the torch has five jets for heating and one larger oxygen cutting jet. The heating jets are arranged in a circle around the central cutting jet, so that a heating flame precedes the oxygen jet regardless of the direction in which the torch is moved, and another heating flame also follows the oxygen jet. It has been found that this arrangement of a heating jet in front and another to the rear of the oxygen jet is much superior to the usual one.

This machine will doubtless prove invaluable in die-making and for a great many other purposes. Fig. 2 illustrates the possibility of cutting out small crankshafts, these shafts having been cut from one-inch steel plates in 8½ minutes. With a high quality of oxygen, the kerf left by the cutting flame is narrow and a clean, sharp cut is obtained. Straight, curved or irregular outlines can be followed easily, and square corners are also cut without difficulty. The piece shown to the right in Fig. 3, was cut out by the writer without any previous experience whatever in operating the machine. This block is illustrated merely to show that straight lines, curves or right-angle turns can be followed by an inexperienced operator. This is made possible by the mechanically propelled tracing wheel, which simply needs to be guided, but takes care of itself as far as the forward movement is concerned. When a corner is reached, the wheel is given a quick turn, and, being motor-driven, immediately starts off in the other direction, so that the corner is cut clean and sharp, which would not be the case if there were any delay. The sides of the narrow path or kerf left by the flame, are remarkably smooth as shown by the sample piece at the left in Fig. 3.

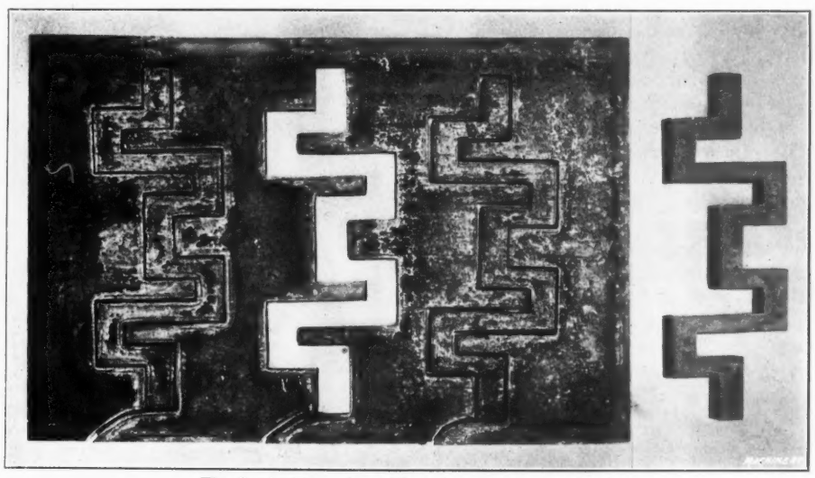


Fig. 2. An Example of Work done by the Oxygraph

The pantograph arm is made of light steel tubing, and the joints are provided with ball bearings to give a free movement. The arm can be adjusted vertically to suit the height of the work, and the drawing-table also has a vertical ad-

justment. The torch tip is about ⅛ inch above the metal when in operation, and the latest designs will have a fine, vertical adjustment of the torch so that its height can be varied in case the material being cut has an uneven surface. This machine has a capacity for widths up to 18 inches, without moving the piece being cut.

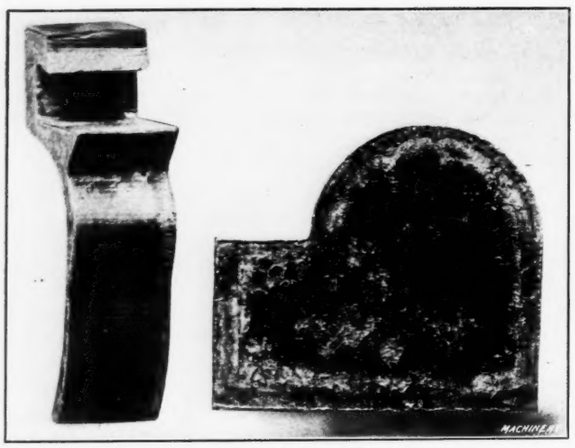


Fig. 3. Sample Pieces cut from Steel Plate by the Oxygraph

The first public demonstration of the oxygraph was given at the Master Mechanics and Master Car Builders convention recently held in Atlantic City, where it attracted considerable attention.

CALDWELL MOTOR-DRIVEN HYDRAULIC WHEEL PRESS

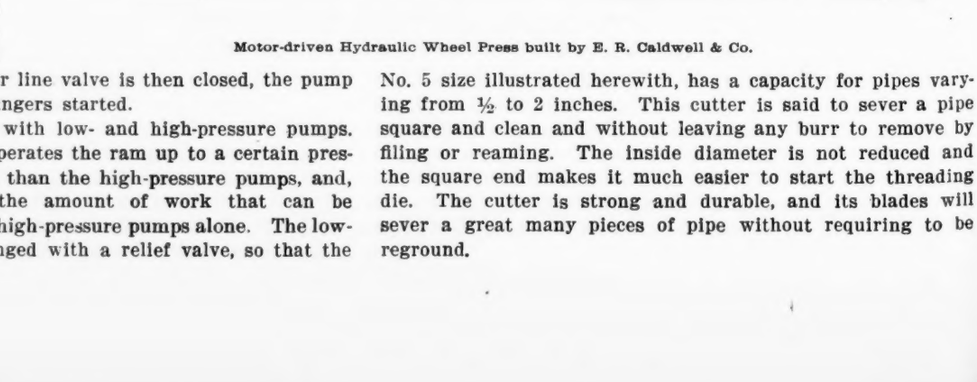
The motor-operated wheel press shown in the accompanying illustration, is manufactured by E. R. Caldwell & Co., Bradford, Pa. This press is a modern design having a rapid adjustment of the ram and a combination of high and low pressures, which facilitate its operation.

For convenience in handling heavy work such as locomotive drivers and irregular-shaped parts that cannot be rolled to and from the press, the upper horizontal parallel bar is not directly above the lower one, but at a slight angle which permits handling the work with an overhead crane. The plungers (not shown in the illustration) are operated by eccentrics on a back shaft which is driven through cut gears having a ratio of 3½ to 1. The plungers operate without vibration and are practically noiseless. The ram is drawn back automatically as soon as the pressure is shut off from the pumps. An extra valve to connect with the city water line is furnished, when it is possible to have such connection. By opening this valve before using the pressure from the pump, the steel-faced ram is moved out against the work more rapidly than would be possible with the pumps; the city water line valve is then closed, the pump valve opened and the plungers started.

The press is equipped with low- and high-pressure pumps. The low-pressure pump operates the ram up to a certain pressure with a greater speed than the high-pressure pumps, and, consequently, increases the amount of work that can be handled by the use of the high-pressure pumps alone. The low-pressure cylinder is arranged with a relief valve, so that the pump works until there is about 50 tons pressure, when it is automatically "cut out" and the pressing operation is continued at a slower rate by the use of the high-pressure pumps.

In pressing off work, this automatic device is especially efficient. The low-pressure pump works until there is about 50 tons pressure and then the high-pressure pumps begin to operate, and continue until the work is pressed off far enough to enable it to be finished with the low-pressure. As will be apparent, this feature enables the work to be done in a minimum of time.

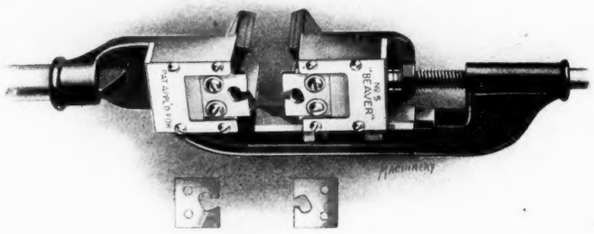
The pump cylinders are cast from a special semi-steel mixture which gives them great strength, and makes them proof against leakage. All presses are provided with a safety valve to prevent overloading. The plungers are driven by a direct-current, 7½-horsepower, Westinghouse motor.



Motor-driven Hydraulic Wheel Press built by E. R. Caldwell & Co.

BEAVER SQUARE-END PIPE CUTTER

The Borden Co. of Warren, Ohio, has brought out a new pipe cutter which severs the pipe by turning or cutting, rather than by squeezing it apart with disks or wheels. This cutter is equipped with square-end turning or parting tools that sever the pipe the same as a lathe tool. The arrangement



Pipe Cutter equipped with Turning or Parting Tools

and form of the tools or blades, and the construction of the central part of the cutter, are shown by the accompanying illustration. There is a tool on each side of the pipe, and, as these tools revolve, a narrow annular groove is cut through the pipe wall. The tools feed inward automatically, and the cutter is turned by two handles the same as a die-stock. The No. 5 size illustrated herewith, has a capacity for pipes varying from ½ to 2 inches. This cutter is said to sever a pipe square and clean and without leaving any burr to remove by filing or reaming. The inside diameter is not reduced and the square end makes it much easier to start the threading die. The cutter is strong and durable, and its blades will sever a great many pieces of pipe without requiring to be reground.

BEAMAN & SMITH CYLINDER BORING AND MILLING MACHINE

The machine shown in Figs. 1 and 2 of the accompanying illustrations is a combination type designed to bore two twin-cylinder automobile engine castings simultaneously, and, at the same time, mill the flanges on two other castings. After one set of castings has been milled, it is moved into position for boring by simply revolving the table.

The machine has a substantial bed which supports at one end a carriage with two boring heads, each of which carries two spindles. This is the head seen to the left in the illustration. At the other end of the main bed there is a small cross bed located at right-angles, upon which is mounted a saddle carrying the two milling spindles. The revolving table is located near the center of the main bed. It is 54 inches square and is provided with a ball bearing, which when raised into position by a handwheel, takes the weight of the table and allows it to be revolved easily. The table, however, does not rest upon this ball bearing when the machine is in operation, but on a scraped surface of large diameter. The table has four stop-pin holes and it can be securely fastened after being located by the locking pin.

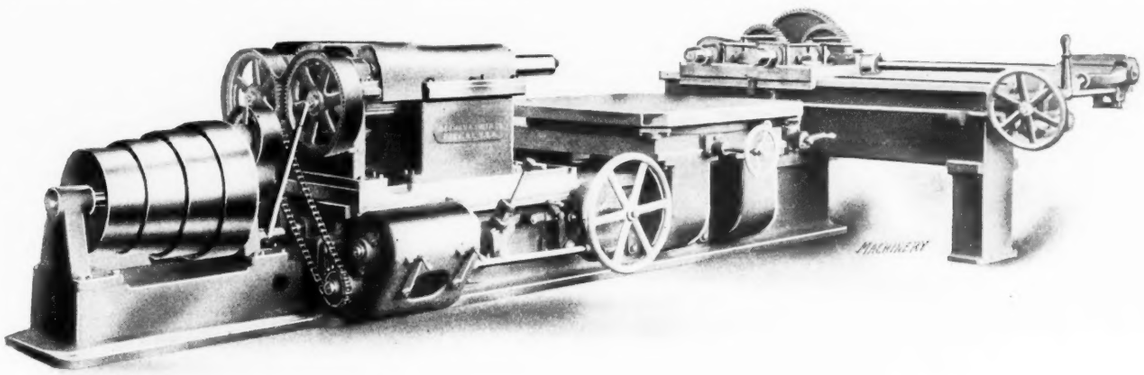


Fig. 1. Beaman & Smith Universal Cylinder Boring and Milling Machine

The carriage upon which the boring heads are mounted, is 34 inches wide, 54 inches long, and has a 30-inch movement on the bed operated by a screw of large diameter which engages a bronze nut. The thrust is taken by ball bearings and the carriage has a quick movement of six feet per minute in either direction. The front end of the carriage extends beyond the ends of the spindles (as shown in Fig. 2) and passes under the table which is bridged across the bed. This extended bearing is for distributing the wear as equally as possible.

The carriage has positive geared feeds which vary from 1/32 to 1/4 inch per revolution of the spindle. The feeds for the milling heads vary from 1 inch to 4¼ inches per minute, for any spindle speed. The four boring spindles are of crucible steel and run in boxes of hard bronze. The ends are made to fit cutters according to specifications. Each of the front bearings is 4 inches in diameter and 6 inches long, and the rear bearings are 2¾ inches in diameter and 5 inches long. Means are provided to compensate for wear. The spindles are fitted in twin heads, and the center distances are made to suit individual requirements. Gearing in the ratio of 8.4 to 1, gives speeds varying from 22½ to 44 revolutions per minute.

The boring spindles are driven by a 6-inch belt operating on a four-step cone, and the milling spindles are driven by a 5-inch belt operating on a three-step cone. The saddle for the milling spindles is 20 inches wide and 41 inches long and has a movement of 52½ inches on the cross bed. It is also provided with a quick power movement, varying from 6 to approximately 12 feet per minute in either direction. This rapid traverse is driven by a 4-inch belt operating on a 10-inch pulley. The milling spindles are also made of crucible steel and run in hard bronze boxes. They have tapered ends 3 inches in diameter for receiving face milling cutters. The front bearings are 4 inches in diameter and 6 inches long, and the rear bearings, 3 inches in diameter and 5 inches long.

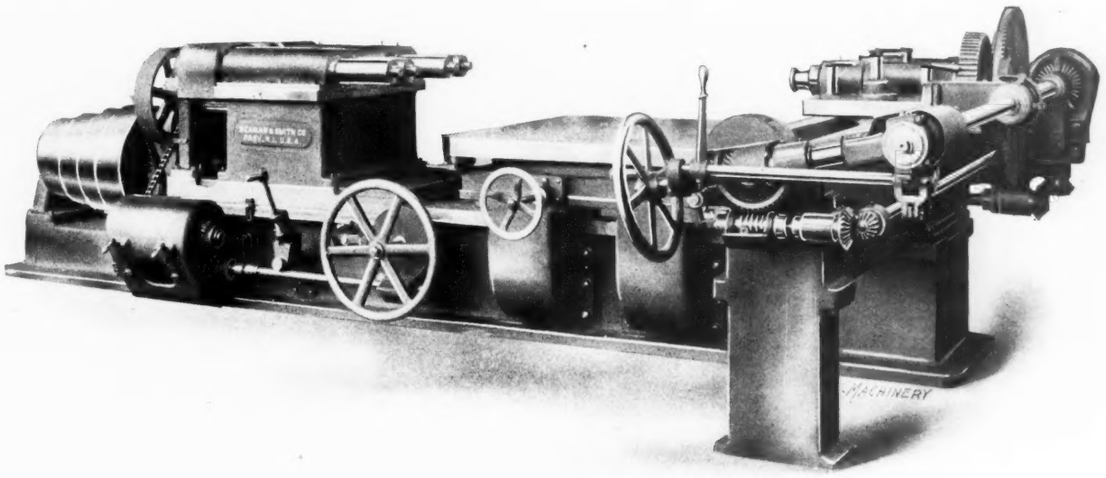


Fig. 2. Another View of the Beaman & Smith Machine

Gearing in the ratio of 21½ to 1, gives speeds of 7½, 10, and 14 revolutions per minute.

The minimum distance from the center of the table to the face of the boring heads is 27 inches, and the maximum, 57 inches. The minimum and maximum distances from the center of the table to the end of the milling spindles are, respectively, 28¾ and 31¾ inches. The vertical height from the center of the spindles to the top of the table is about 9¾ inches. The weight of this machine is approximately 28,000 pounds. It is known as the No. 2 universal, cylinder-boring and milling machine, and is built by the Beaman & Smith Co., Providence, R. I.

OESTERLEIN MOTOR-DRIVEN MILLING MACHINES

The application of variable- and constant-speed motor drives to the milling machines built by the Oesterlein Machine Co., Cincinnati, Ohio, is illustrated herewith. Fig. 1 shows a direct-connected, variable-speed, motor-driven machine. This same drive is applied to all sizes of plain and universal milling machines built by this company. A large driving gear, which runs loose on the spindle, drives the latter either by connection to the face-gear or through the back-gearing. The intermediate gear is made of hard fiber so that the drive is practically noiseless. With the push-button starter, which is located on the right side of the column above the spindle, the machine is automatically adjusted to the speed for which the motor is set.

The No. 20 plain or universal machines are equipped with a two-horsepower motor, and with a 6 to 1 speed variation all spindle speeds from 19 to 400 revolutions per minute can be obtained. A 4 to 1 variable-speed motor will give all speeds from 21 to 85 and from 100 to 400 revolutions per minute. For the single back-geared No. 24 or 28 plain and No. 25 universal machines, a three-horsepower motor is used, and with 6 to 1 and 4 to 1 variations, the same spindle speeds are obtained as previously given for the No. 20 machines. A double back-geared No. 24 plain, No. 28 plain, and No. 25 universal machine should have a three-horsepower motor, and a 3 to 1 variable-speed type will give all spindle speeds from 14 to 400 revolutions per minute. The No. 34 plain and No. 30

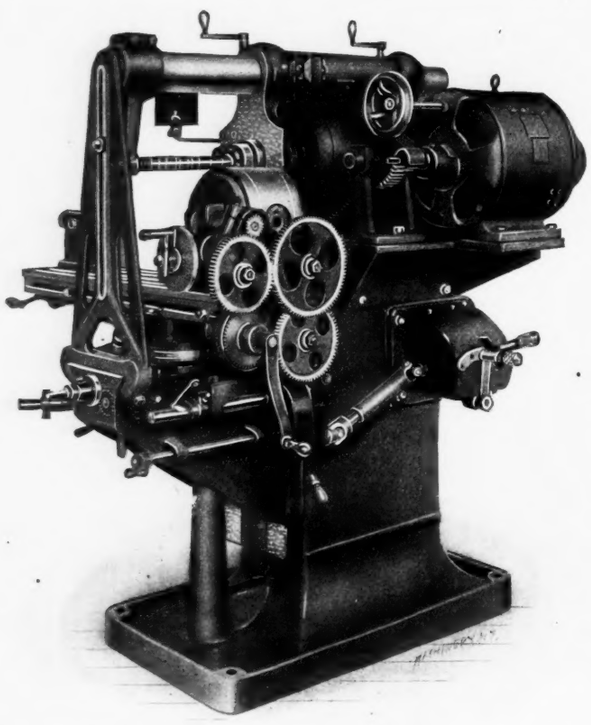


Fig. 1. Oesterlein Direct-connected Variable-speed, Motor-driven Machine

universal machines use a five-horsepower motor. The spindle speeds in any case can be changed by altering the pinion on the motor shaft.

A constant-speed motor-driven machine is illustrated in Fig. 2. The arrangement of the drive is clearly shown by the illustration. The motor may be an alternating or direct-current type. The motor shaft carries a two-step pulley which drives the two-step pulley on top of the machine. On this upper pulley shaft there is a pinion which drives a large gear inside the cone. This gear is secured to the cone, and the latter is bronze-bushed and runs loose on the shaft. The upper pulley shaft is eccentrically mounted and its position can be varied by the belt-tightening lever seen on the right-hand side of the cone. With this lever, a proper belt tension can be secured or the belt can be loosened to permit shifting it easily. The lever between the two cones is provided to facilitate the shifting of the belt.

The single back-geared machines have four-step driving cones operating at two different speeds, so that, in connection with the back-gear, 16 single speeds are secured. The double back-geared machines have three-step driving cones, which, with two speeds and double back-gears, give 18 spindle speeds

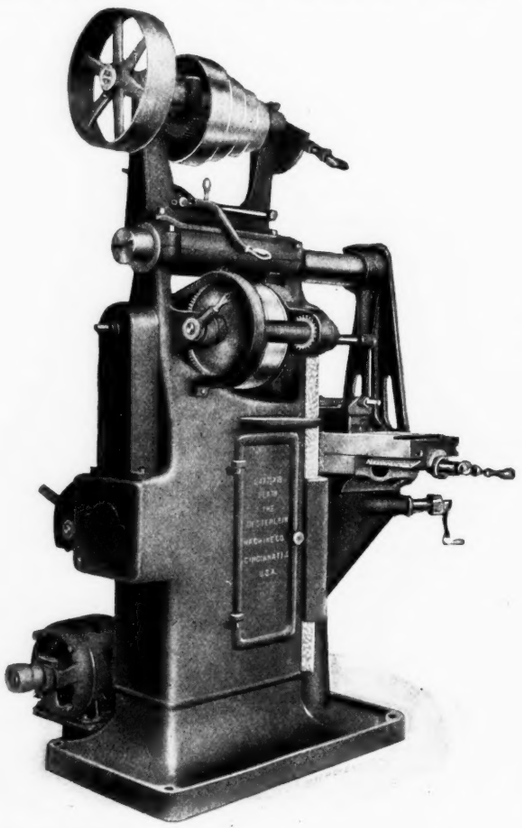


Fig. 2. Oesterlein Constant-speed Motor-driven Machine

varying in geometrical progression. A two-horsepower motor is recommended for the No. 20 plain and universal machines; a three-horsepower size for the No. 24 and 28 plain, and No. 25 universal machines, and a five-horsepower motor for the No. 34 plain and No. 30 universal machines.

CINCINNATI PRECISION ADJUSTABLE REAMER

The adjustable reamer shown in Fig. 1 has been designed by the Cincinnati Precision Lathe Co., Cincinnati, Ohio, for accurate work. The blades of this reamer are inserted in slots cut in a steel shell which is fitted to a taper shank, and held in position by a taper pin which passes radially through

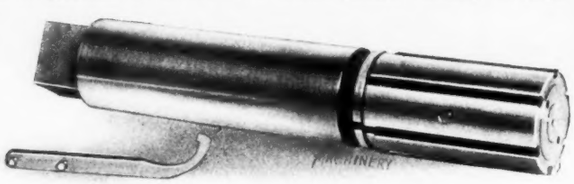


Fig. 1. Cincinnati Precision Adjustable Reamer

both shell and shank. The slots extend clear through the shell, excepting at each end, so that the blades rest directly upon the taper shank. The latter is threaded at each end of the taper, and upon the threaded parts are screwed angular collars which retain the blades, as clearly illustrated in Fig. 2, which shows the reamer with the slotted shell and the angular collars removed.

The blades are also adjusted radially by these collars, the adjustment being made by screwing the collars one way or the other and thus shifting the blades up or down the taper

shank. By employing a ground taper shank as a seat for the reamer blades, a fine degree of accuracy is obtained. The blades, which are jig ground, are exact duplicates, and the slots in the shell are accurately milled to fit the blades.

This construction gives a uniform movement and adjustment of all the blades, so that each one cuts when the reamer is in use. By adjusting the collar next to the body and then turning the collar at the small end of the taper shank, a corresponding amount, the blades are moved along the taper

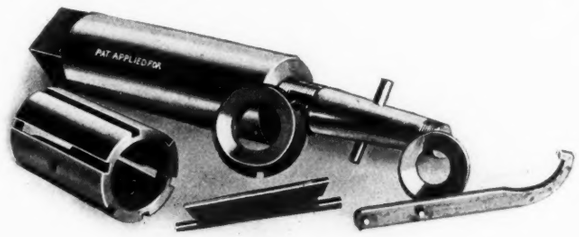


Fig. 2. Component Parts of Adjustable Reamer

uniformly and cannot become eccentric to the body of the reamer. The inner sides of the collars, which engage the ends of the blades, have a 30-degree angle so that the blades are firmly clamped against the taper shank. All threads and inner working parts of this reamer are protected from chips or other foreign material. The single combination wrench seen in Fig. 1, is used for making all adjustments.

MODERN MACHINE TOOL CO.'S FLAT TURRET LATHE

The Modern Machine Tool Co., 4657 Spring Grove Ave., Cincinnati, Ohio, is now manufacturing the flat turret lathe shown in Figs. 1 and 2. Careful attention has been given to the arrangement of the various parts so as to secure a compact, simple construction and a convenient control. The various parts of the lathe have been made extra heavy.

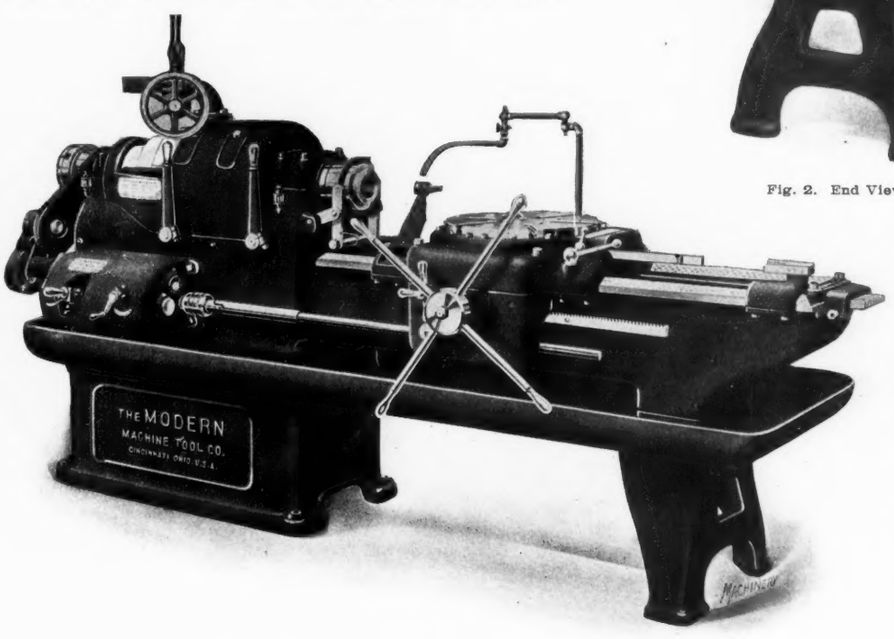


Fig. 1. Flat Turret Lathe built by Modern Machine Tool Co.

The head is very massive and is cast integral with the bed. The head contains the cone pulley for driving the machine, the friction back-gears and the automatic roller feed and chuck. The back-gears are located directly under the spindle. These gears, in conjunction with the three-step cone, give 12 spindle speeds varying in geometrical progression. The bed, which rests on a tripod bearing, is deep and heavy, and is reinforced under the front spindle bearing.

The chuck is operated by a single movement of the lever seen in front of the head. It has a strong unyielding grip and no overhang or end motion. One set of jaws can be adjusted for the full capacity of the machine, and the jaws and seat are hardened and ground. The chuck is constructed for handling rough bars, and the jaws can be made for any size or shape within the spindle's capacity. The automatic roller feed has only three moving parts. It is mounted on the spindle just back of the front bearing and is operated by the same lever that opens the chuck.

The carriage is gibbed to the outer edge of the bed by flat gibs extending its entire length. The bearing on the bed is not recessed, but there is a full contact from end to end. A binder is provided for securely clamping the carriage to the bed during forming or cutting-off operations. The backward movement of the carriage automatically indexes the turret the instant the tool leaves the work. The arrangement is such that the turret can be turned to any one of the six positions without making any other stops.

Fig. 2. End View of Flat Turret Lathe

The adjustable dog for operating the index bar is clamped to the V and governs the position of the saddle at the time the turret begins to revolve.

The carriage has twelve independent adjustable stops which operate automatically for each position of the turret and can be used in any desired combination when two or more are needed for any position of the turret. The turret is a flat circular table 18 inches in diameter, and has T-slots for clamping the tools in position. The tools can be attached to the turret for turning several diameters simultaneously when desired. The index is very large in diameter and the lock-bolt is located directly under the working tool, and so close to it that lost motion is eliminated.

The feed gear box is driven from the spindle. Eight feed changes are available for each of the twelve spindle speeds, and a graduated plate shows the amount of feed for different positions of the change gear levers. All gearing is covered.

The machine has a mechanical belt shifter which is operated by a handwheel located at the front of the head. This wheel operates two shifting arms, one of which is located

above the cone pulley on the machine and the other near the cone pulley on the countershaft. Connection is made between the upper and lower arms by a vertical shaft. By means of this mechanical shifter, the position of the belt can be changed quickly and without danger to the operator.

Bar stock up to 2¼ inches in diameter can be fed through the automatic chuck and lengths up to 26 inches can be turned. The swing over the bed is 20 inches, and over the carriage, 16 inches. The net weight of the machine is 4500 pounds. This lathe is manufactured on the unit system and the parts are interchangeable. The plain bearings are scraped to master surface-plates and straightedges, whereas shaft bearings are ground and fitted with removable bushings which can be replaced when worn, without disturbing the shaft alignment. Efficient means for lubrication are provided.

WILMARTH & MORMAN CUTTER, REAMER AND DRILL GRINDER

The cutter, reamer and drill grinder manufactured by the Wilmarth & Morman Co., 580 Canal St., Grand Rapids, Mich., has been re-designed to make it more universal than the former machine. With the old-style grinder, the table of the cutter grinding attachment was permanently bolted to the column and the small wheel-head was bolted to the table. With the new machine, the table and its slide is mounted on a knee so that it can be swiveled with relation to the grinding wheel, approximately 180 degrees, which permits using a cup wheel and makes it possible to apply the work to either side of a plain wheel.

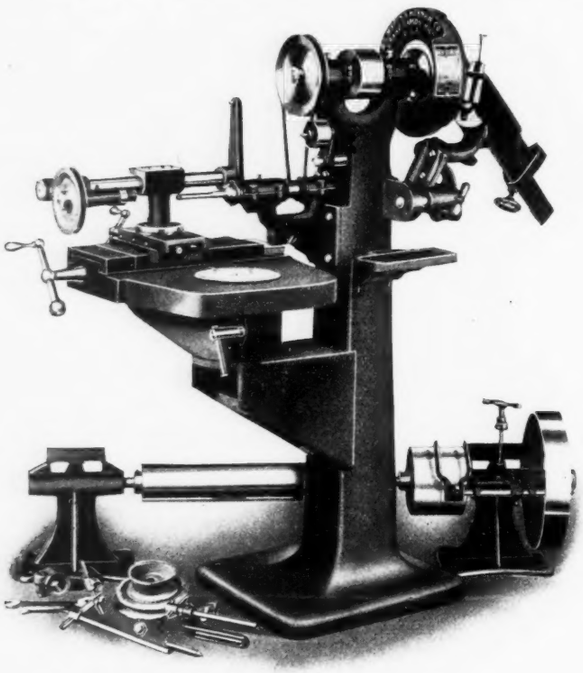


Fig. 1. "Yankee" Cutter, Reamer and Drill Grinder with Cylindrical and Internal Grinding Attachment

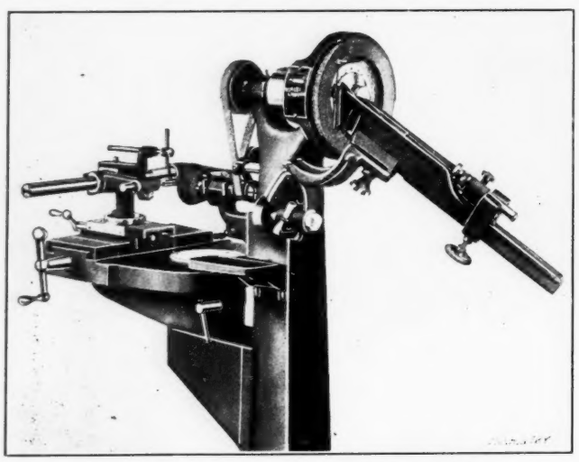


Fig. 2. Grinding Reamer with Face of Cup Wheel

Fig. 1 shows the machine complete, with a cylindrical and internal grinding attachment, in addition to the regular drill grinder. The way the machine is arranged for grinding reamers when using the face of a cup wheel, is illustrated in Fig. 2. This particular reamer is straight, but taper reamers are ground in the same way, except that the standard carrying the reamer, is swiveled to the required angle. In case it is desired to grind a reamer by using the periphery of a plain wheel instead of a cup wheel, this can be done by swinging the table around to bring the slide parallel with the wheel spindle. The table can be swiveled to either side, so that the wheel will grind either up or down, with relation to the teeth.

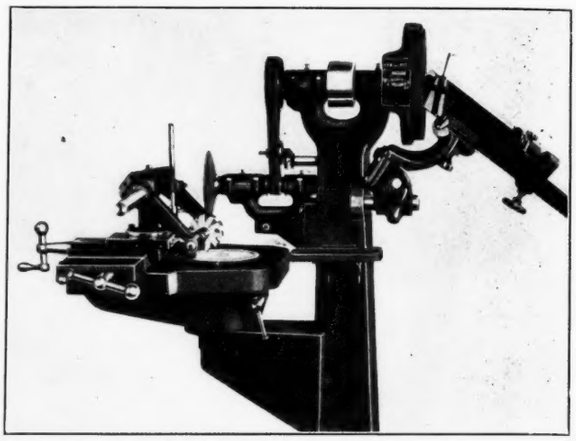


Fig. 3. Grinding Formed Cutter

Fig. 3 illustrates the grinding of a formed cutter. The work is mounted on a suitable arbor which is placed between the centers, as shown, and the teeth are ground by passing the cutter under a saucer-shaped wheel. The feed is regulated by the cross-screw movement of the upper or cross-slide which carries the swivel or standard. Hobs, gear-cutters or taps can also be ground in the same way. When grinding the flutes of a tap, the latter is, of course, held by its own centers and no arbor is needed. Fig. 4 shows the method of grinding a plain, spiral-tooth milling cutter by using the periphery of a straight wheel. A cup wheel can also be employed by setting the machine as illustrated in Fig. 2.

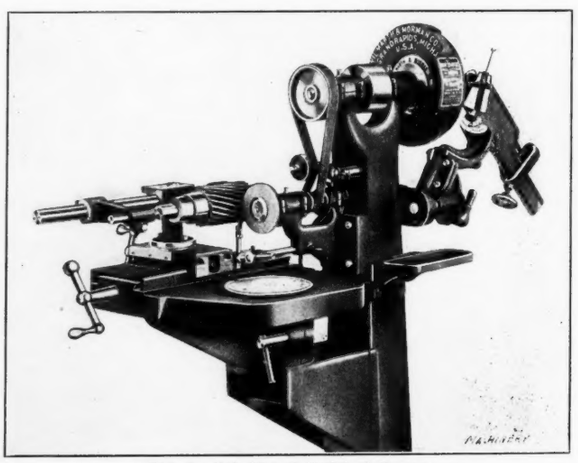


Fig. 4. Grinding Cylindrical Cutter

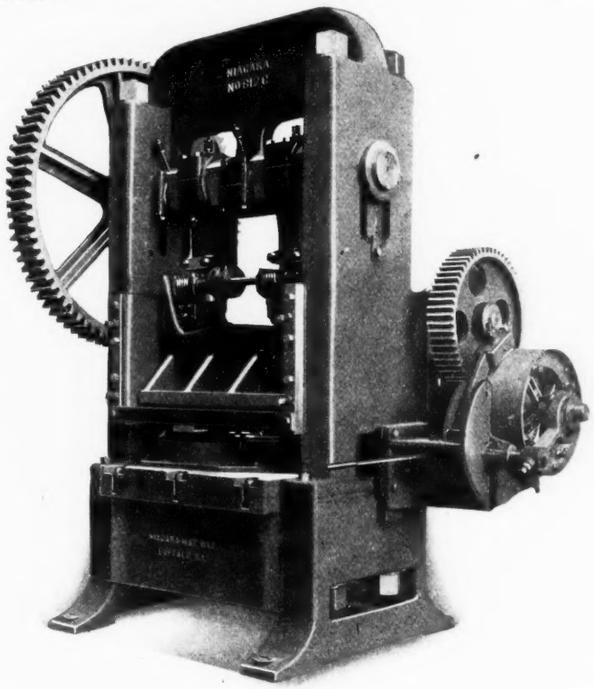
This machine is also adapted to the grinding of angular cutters, as well as face or side mills. When grinding angular cutters, the table is swiveled to the required angle as indicated by the graduated base. A vise can be furnished with this machine in case it is to be used for surface grinding. This vise is interchangeable with the regular swivel standard and has a graduated base which can be swiveled for angular grinding. The vise can also be tilted in a vertical plane, from

a 45-degree position to a point slightly beyond the perpendicular, and provision is made for securely locking it in position. This vise is intended for small hardened parts, such as vise jaws, small tools, cutters, keys, etc.

This machine has a capacity for side and face milling cutters up to 12 inches in diameter, and angular or plain cutters up to 8 inches in diameter. It will grind cylindrical work (straight or taper) up to 7¼ inches in diameter and 11½ inches long. The maximum distance between the centers is 17 inches.

NIAGARA DOUBLE-CRANK PRESS

The straight-sided, double-crank, power press shown in the accompanying illustration, was recently designed by the Niagara Machine & Tool Works of Buffalo, N. Y. The press



A Large Double-crank Press built by Niagara Machine & Tool Works

was built for the manufacture of gear guards for electric traction engines, but is suitable for a general line of heavy stamping and blanking operations. The frame is of the built-up type with tie-rods, and the slide and gibs have convenient adjustments.

Particular attention has been given to the arrangement of the press, so as to obtain a compact design occupying a minimum amount of floor space. Outboard bearings are entirely eliminated, and all parts of the drive which require occasional adjusting, are easily accessible.

The friction clutch is of the multiple-disk type. The friction surfaces are lined with end grain hardwood blocks. The clutch is entirely encased and all projecting rotating parts which might endanger the operator when oiling the clutch, are eliminated. The clutch is operated by four sets of toggles and links, which are made of steel. The brake which works in unison with the clutch, consists of two brake levers, which are actuated by a pair of toggles. An interesting feature of this construction is that the pressure on the brake blocks is always equalized, thus avoiding transmitting the pressure of the brake arms to the shaft bearings.

These presses are built in different sizes varying from 48 inches to 12 feet between the housings, and weighing from 30,000 to 150,000 pounds.

ROCHESTER BORING, MILLING, DRILLING AND TAPPING MACHINE

A horizontal boring machine of the "table type," which embodies many interesting features, has been brought out by the Rochester Boring Machine Co., Rochester, N. Y. This machine, besides performing the usual operations of boring,

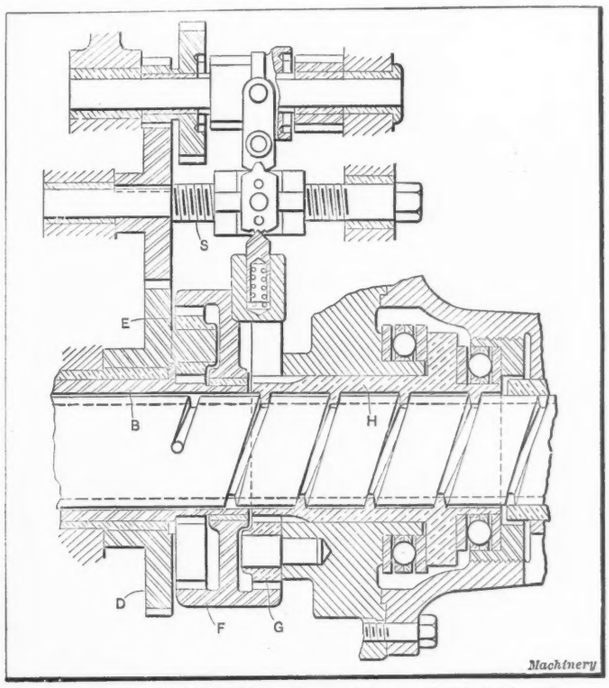


Fig. 1. Differential Feed Mechanism and Automatic Limit Stops for Spindle of Machine shown in Fig. 2

milling, and drilling, can also be arranged for tapping, splining oil grooves or thread cutting. The control of the machine is centralized, it being possible to make feed or speed changes, operate the rapid traverse movements, or start, stop and reverse the machine from one position convenient to the operator. No two feeds can be engaged at the same time, and it

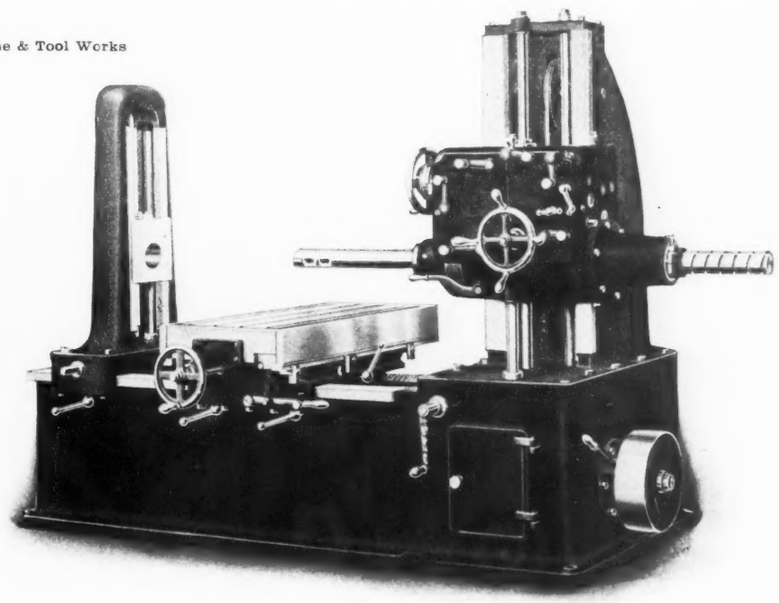


Fig. 2. Rochester Boring, Milling, Drilling and Tapping Machine

is also impossible to engage simultaneously the rapid traverse for different directions.

The main drive through the bed to the operating mechanism is simple and direct. The pulley shaft can be arranged either parallel to the machine, as shown, or at right-angles to the bed. The single, constant-speed driving pulley has a friction clutch for starting or stopping, which is controlled by the

small lever seen to the left of the pulley in Fig. 2. The horizontal lever on the lower left-hand corner of the saddle, can also be used for starting, stopping or reversing. This machine can be equipped with a motor drive, if desired. For a standard electric drive, the motor is mounted at the top of the column and connects direct with the vertical driving shaft. The motor can, however, be applied to the driving pulley shaft, if desired. Constant-speed motors for either alternating or direct currents are used, as all speed changes are obtained mechanically.

The bed has a continuous web construction and is closely ribbed in both directions. Chutes are provided in the bed for removing chips at the rear, and there is also a reservoir in one end for cutting oils or lubricants. The upright column upon which the saddle travels, is bolted and doweled to the bed and has a deep section with large surface bearings.

The mechanism for feeding the main spindle operates on the same principle as the feed mechanism illustrated in MACHINERY for July, 1910, in connection with a description of the floor-type machine built by this company. The feeding movement is transmitted from the change-gear mechanism to a differential geared drive which rotates a long bronze nut mounted directly on the spindle and engaging a square thread. The driving gears for the spindle are mounted on a sleeve *B* (see detail sectional view, Fig. 1) which has its own independent bearings. Clearance is provided between the sleeve and spindle and the latter is rotated by long splined keys fitted in the driving sleeve and engaging double splines, thus giving a balanced drive. Sleeve *B* has gear teeth cut on the end shown in Fig. 1, which mesh with three pinions *E* mounted on studs that form part of the differential feed-driving gear *D*. By means of a double internal gear *F* and three other pinions *G*, which mesh with the spindle feed nut *H*, the latter is positively rotated at the same speed and in the same direction as the spindle, so long as gear *D* remains stationary, which is the case when the feeds are disengaged. When the feed is applied, the spindle nut either rotates faster or slower than the spindle and this differential movement between the nut and spindle, gives a feed in one direction or the other.

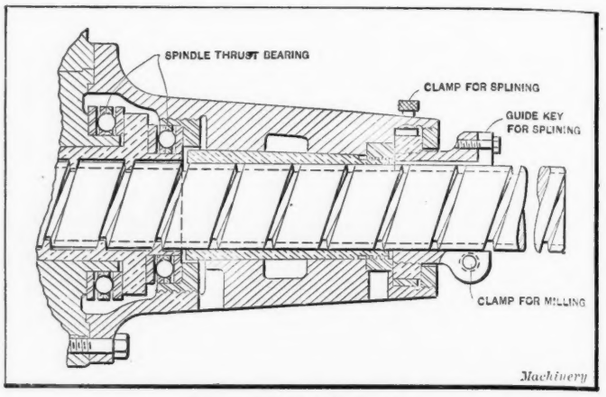


Fig. 5. Rear Spindle Bearing

The nut makes contact with the sides of the thread only, and the end-thrust is taken direct by the large ball bearings shown. The end-thrust for milling is taken by a bronze thrust bearing independent of the end-thrust for boring. All feeds, before being applied to the different parts, are transmitted through a friction clutch which enables instantaneous engagement or disengagement and provides a yielding point when desired. The reverse mechanism is located at the source of power and the feed can be reversed without stopping the machine.

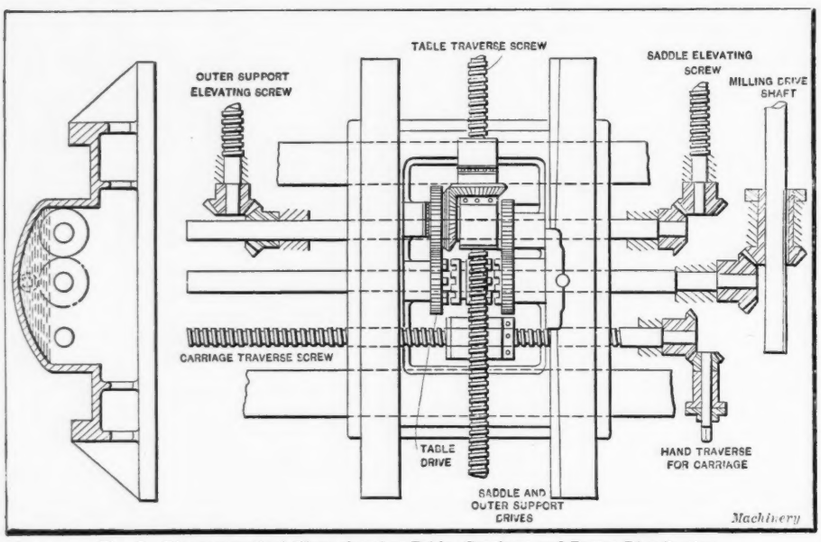


Fig. 3. Diagrammatical View showing Table, Carriage and Power Distribution

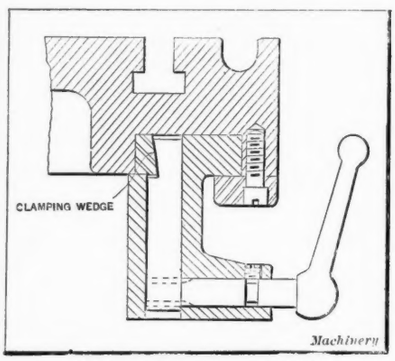


Fig. 6. Locking Clamp for Table

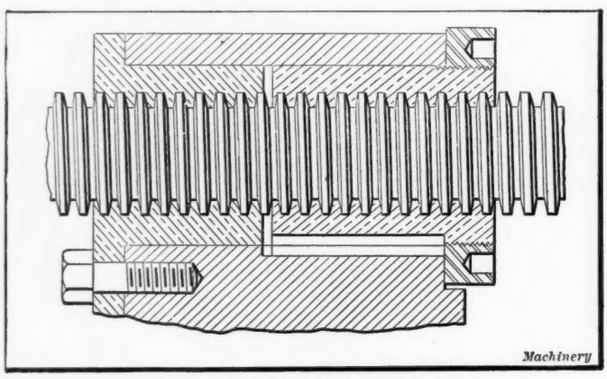


Fig. 4. Two-part Nut for Taking up Wear

Sixteen boring and drilling feeds are provided and a similar number of different milling feeds for the saddle and table. These feeds and the rapid power traverse, are applicable to the spindle, saddle, table and carriage. Automatic limit stops are arranged for movements in either direction, in addition to adjustable knockouts for the table feeds. It is impossible to engage two feeds, speeds or traverses at the same time. The driving and feed gearing is enclosed and runs in oil. The lubricant is forced to a reservoir at the top of the saddle by a pump and from there it is distributed by leaders to the different bearings, and the overflow runs over the gears.

The feeding and traversing movements are transmitted to the table through a vertical shaft in front of the saddle and a shaft in the bed. At the table the feed is distributed either for the cross-wise movement or for elevating the saddle and outer support. Fig. 3 shows a diagrammatical plan view of the carriage for the table and illustrates the arrangement of the mechanism. A power cross feed is provided for the table and also a power lateral traverse for the carriage, when specified. The nuts for the screws are made in two parts, as shown in Fig. 4, for taking up wear or backlash. One section of the nut has a flange, as shown, and the other part can be adjusted longitudinally by a threaded collar, but is held against rotation.

The bearings for the spindle are located at the extreme ends of the saddle, thus giving a rigid support. A sectional

view of the rear bearing is shown in Fig. 5. These bearings are of phosphor-bronze and can be easily adjusted from the outside, in case of wear. The knockout or limit stop for the extreme travel of the spindle is shown in Fig. 1. An intermediate gear located between the feed change gears and the feed driving gear, rotates screw *S*. A nut on this screw is moved a certain predetermined distance, representing the maximum travel of the spindle. At the extreme travel of the nut, a lever segment is automatically actuated, which disengages the feed back-gear clutch and throws it to the neutral position, thereby stopping the feed.

When the machine is used for splining, the spindle is moved in and out without rotating, by the rapid power traverse. The spindle gear clutch is set in the neutral position, thus disengaging the spindle driving gears, and a guide key (see Fig. 5) is inserted in the milling clamp collar at the end of the saddle. This key engages one of the splined ways in the spindle, and the collar is held against rotation by a friction band which is tightened by a thumb-screw on the outside of the bonnet. Both the collar and spindle are held in this way against rotation, and the spindle is guided, as it moves lengthwise, by the key previously referred to. Spiral oil grooves of different pitches can also be cut by using the rapid power traverse in conjunction with the rotary movement of the spindle. When cutting spiral grooves, the clamp collar used for straight grooving is, of course, disengaged.

Graduated dials reading to thousandths of an inch are provided for all movements, and precision screws are used throughout. On the front end of the saddle there is an "indicator" corresponding to the center of the spindle, which is convenient for adjusting to a given height with a surface gage, when boring. The table is clamped directly under the spindle and the form of locking binder used is shown in Fig. 6.

These machines are built in two sizes at the present time, the principal dimensions of which are, respectively, as follows: Spindle diameter, 3 and 3½ inches; longitudinal traverse of spindle, 32 and 40 inches; spindle speed changes, 12 for both machines; feed changes, 16; vertical traverse of saddle, 21 and 25 inches; maximum height from table to spindle, 22 and 26 inches; maximum distance between saddle and outer support, 5 feet and 6 feet; table cross-feed, 30 and 36 inches; lateral traverse of table, 36 and 42 inches. These machines are so constructed that the standard range can be varied easily to suit special requirements, when necessary.

GARVIN AUTOMATIC-INDEX MILLING MACHINE

The milling machine shown in Fig. 1 is an automatic-indexing type, especially adapted to tap manufacturing plants. This machine is built by the Garvin Machine Co., Spring and Varick Sts., New York. In addition to the automatic fluting of taps and reamers, the machine can be used for cutting gears, ratchets or for repetition work of a similar nature. The modifications introduced in this design comprise quick-acting work-holding apparatus, automatic indexing, automatic feed with a quick return effected by a long spring and checked by an air cushion, and automatic stopping of the machine when the work is completed.

When a cut is finished, the table is tripped by the dog seen to the left, which releases a latch and allows the feeding worm to drop out of mesh with the worm-gear. As the table is then disengaged from the power feed, it is moved rapidly to the other end of its travel by a spring enclosed in a tube at the end of the table. The arrangement of the feed gearing and quick-return mechanism is shown in Fig. 2. The rapid motion of the table is checked before the fixed stop is reached, by an air cushion formed in the cylinder shown by the section to the right.

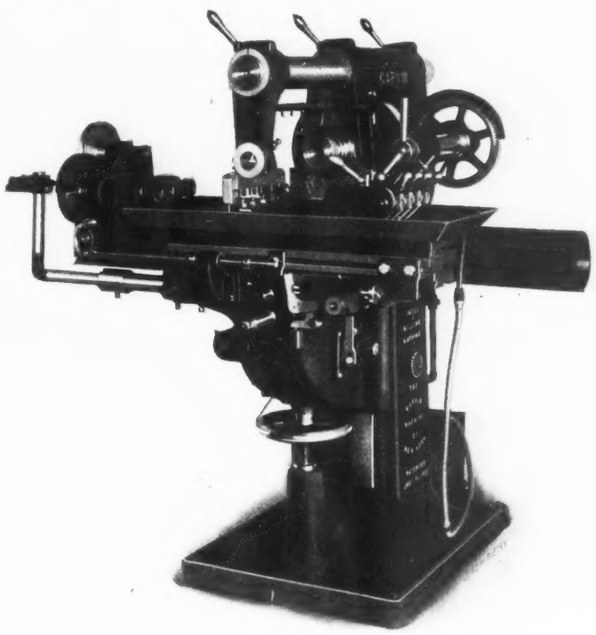


Fig. 1. Garvin No. 13 1/2 Automatic-index Milling Machine

At the same moment that the dog trips the table, the left-hand stop-collar on the screw seen in front of the machine to the left, Fig. 1, comes in contact with a stationary bracket; this trips the tilting table of the machine by means of a cam shown to the left in Fig. 2, the shaft carrying this cam being operated by the longitudinal movement of the screw on which the stop-collar is mounted. As the cam is turned, the table swings downward slightly, the swiveling movement being around a pivot at the right-hand end. This prevents the cutter from dragging when the work is being returned for another cut. As the table approaches its extreme position on the return stroke, the right-hand dog at the front strikes a stop-plunger, thus shifting the worm back into mesh with the worm-gear at the same moment that the table comes to rest. As the table reaches the end of its travel, the right-hand stop-collar on the screw previously referred to, strikes a stationary bracket and operates the cam lifter, thus tilting the table back to its working position. The index pawl is also lifted so that the dial can index, after which it falls back instantly.

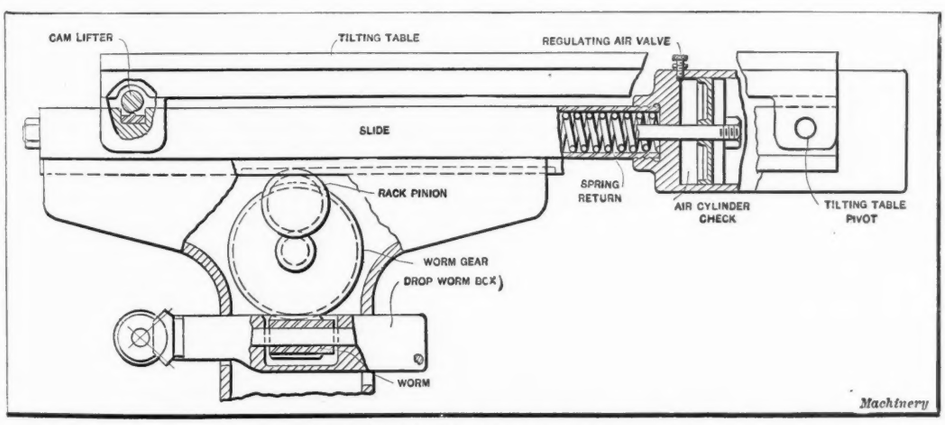


Fig. 2. Feeding and Quick-return Mechanism of Garvin Machine

The machine is now ready for another cut, and this operation of feeding forward, returning rapidly and indexing, continues until the work is finished. The machine then trips

again and, on indexing, a projecting pin on the index dial pushes a sliding pin on the telescope bar seen to the left of the machine, and releases a rope connecting with a spring on the countershaft, thus stopping the machine.

The maximum distance between the centers is 16 inches, and a cut 7½ inches long can be taken anywhere within this distance. The centers have a capacity for holding work on all four spindles up to 2 inches in diameter, and diameters up to 4 inches can be handled, when only the two outer spindles are used. The weight of the machine is 2200 pounds.

HOSKINS RECORDING PYROMETER

A new recording pyrometer which is now being built by the Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich., is shown in Fig. 1. The record chart of this pyrometer is always visible, thus making the instrument "indicating" as well as recording, and the electrical movement, as well as the clock and marking device, is at all times entirely enclosed, even when changing charts. In designing this pyrometer, the principal points aimed at were accuracy, reliability and simplicity.

The electrical movement of the pyrometer is a finely built milli-voltmeter of the D'Arsonval type. It is sensitive to a fraction of a milli-volt and was especially designed for this pyrometer. It is claimed that this milli-voltmeter is much less susceptible to outside temperature conditions than the ordinary types. It is actuated by the electro-motive force

Fig. 1. Recording Pyrometer made by Hoskins Mfg. Co.

set up by a base metal thermo-couple which is connected by wire leads to the binding posts shown at the bottom of the meter case. This thermo-couple, when subjected to heat, is said to generate an electro-motive force four times as great as that of the ordinary platinum-rhodium couple, for a corresponding temperature; the additional power thus gained adds to the accuracy and reliability of the pyrometer.

The record chart is caused to revolve by a clock movement contained within the meter case. The chart is a circular disk of paper which is thin and translucent but strong and durable. It is clamped in place on the revolving clock shaft by a small thumb-screw. A circular disk of carbon paper of the same size as the chart, is also clamped on the shaft, back of the chart and with the carbon side toward it. When a chart is being put in place, as shown in Fig. 2. it is held temporarily against a stationary dial-plate which completely covers the electrical and clock movements.

The clock also actuates an arm which is curved to correspond to the arc through which the end of the recording pointer travels. At half-minute intervals the curved arm momentarily brings a small stylus or metal point, carried at the end of the recording pointer, against the carbon paper, thus making a dot on the back of the chart. As the chart revolves, these dots, which are plainly visible from the front, continue to be made, giving the appearance of a continuous line, as shown in Fig. 1. The location of the dots relative to the concentric circles printed on the chart, indicates the temperatures to which the thermo-couple has been subjected. The charts are made to indicate degrees Centigrade or Fahrenheit, or milli-volts, as desired, and to cover periods of twelve or twenty-four hours.

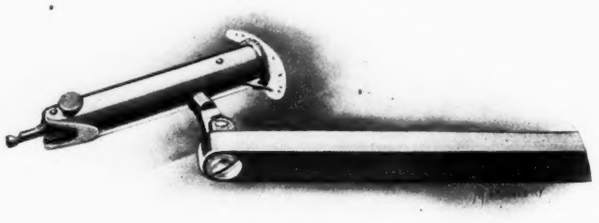
This method of making records permits two records to be made at the same time, just as duplicate letters are made on the typewriter. When a considerable number of copies of any particular record are wanted, blueprints may be made directly from the chart. On the margin of the chart, a place is provided upon which to mark the date and time at which the

Fig. 2. Placing a New Chart in Hoskins Pyrometer

record was started and the name of the furnace or operation. This pyrometer is especially desirable when it is necessary to intrust it to the care of an unskilled workman, as there is no exposed mechanism which the operator can put out of order. There are no pens or other inking devices to look after, and when the chart is removed from the meter, it is complete and ready for use, and requires no "fixing" solution as in the case of sensitized charts. As one sheet of carbon paper is sufficient for twenty records, the cost for carbons is very small. With the exception of the clock movement, which is a Seth Thomas standard eight-day movement, every part of the pyrometer is made by the Hoskins Mfg. Co.

UNIVERSAL TEST INDICATOR

The universal test indicator illustrated below is made by the Alvan Mfg. Co., Newark, N. J. This indicator has hardened cone-pivot bearings which are kept in constant uniform adjustment by spring thrusts that prevent lost motion and consequently errors in reading. These cone bearings also



Universal Test Indicator

make the indicator very sensitive, and it is claimed that no adjustment is ever required.

The indicator proper is attached to the toolpost holder by a universal joint, which is frictionally held in any desired position. By means of this joint the indicator can be set at any angle with relation to the shank. Either side of the contact point can be used, and the spring tension is reversed by half a turn of a button on the end of the barrel. This indicator multiplies error in the ratio of 50 to 1, and has a capacity up to 0.020 inch.

NATIONAL DROP-ARM SPOT WELDER

The National Electric Welder Co., Warren, Ohio, has recently placed on the market a new electric spot-welding machine which has been designed to combine the advantages of the regular horizontal machines with those of the special swing and drop-arm types. In designing this welder, the idea was to so construct it that such work as welding the side seams of a box or tube, a well as the bottom of a box or can, could be accomplished.

The lower arm was made adjustable to adapt the welder to a wide range of work. The front face of the column is machined and carries gibs, one of which is held in place by studs and nuts. By loosening the nuts, the supporting bracket with the low tension leads and welding point can be adjusted to any convenient height with relation to the upper point. The movement is effected by the wrench shown just below the horizontal arm, which operates a pinion mounted inside the bracket. This pinion meshes with a rack on the inside of the bed-plate, and has ratchet teeth on the side which are engaged by a spring-pin on the adjusting handle.

National Drop-arm Spot Welder

The current is conducted to the lower bar and welding point by the heavy copper conductor shown. This conductor is machined to fit into the end of the movable bar, and a solid and efficient contact is made at this point. The upper overhanging arm is of cast iron and is designed to resist springing or deflection, when subjected to the pressure required for making satisfactory welds.

This welder is known as the drop-arm type, and it is built in three sizes, having distances between the center of the welding points and the face of the machine of 12, 24 and 36 inches, respectively. The movable arm on all of these sizes can be dropped 25 inches from the highest point at which it can be used.

These machines have a combination hand and foot lever control. If the work being welded is of such a nature that the operator can use both hands to advantage in holding it, the welding points and switch can be operated by the foot lever, and, if desired, the hand lever can be removed. The machine can be also hand operated, in which case the foot treadle can easily be removed.

The machines are equipped with an automatic switch which operates only after the welding points are brought firmly into contact with the work. The act of releasing the pressure, whether using the foot- or hand-lever control, causes the switch to open, which prevents injury to the work or welding points by separating them after the welding current is broken. The copper contacts are cooled by a stream of water which is conducted to within ¼ inch of the faces bearing on the heated metal. In this way the parts are kept cool and the burning or "mushrooming" of the copper points is avoided.

TOLEDO ELECTRIC WELDERS

The Toledo Electric Welder Co., Langland & Knowlton Sts., Cincinnati, Ohio, has brought out a new welding machine designed especially for welding flat tires varying from ¾ by ¼ inch up to 2 inches by ¼ inch, or 1¾ by ⅜ inch. This is

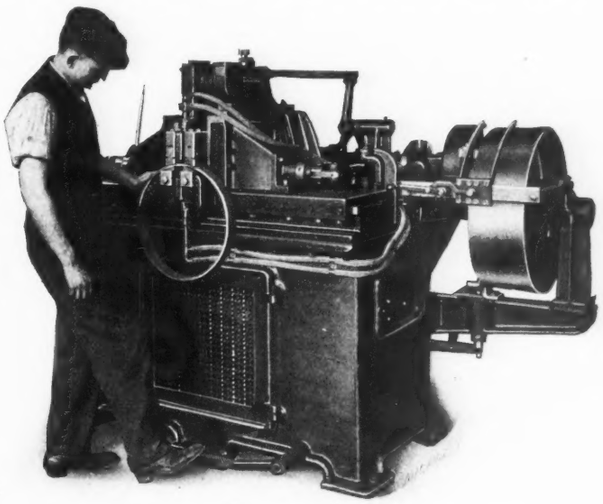


Fig. 1. Toledo Power-driven Machine for Welding Flat Tires

a power-driven machine and it will electrically weld a 1¼- by ¼-inch tire in 13 seconds.

In the operation of the machine the tire is placed in the jaws of the welder, as shown in the illustration; the workman then presses a foot lever, the clamping jaws close on the stock and the ends are brought together. The current is automatically turned on, and in a few seconds the iron is raised to the welding temperature. When the heat is just right a second pressure on the foot lever automatically turns off the current and forces the ends of the stock together. At the same time two steel dies located between the clamping

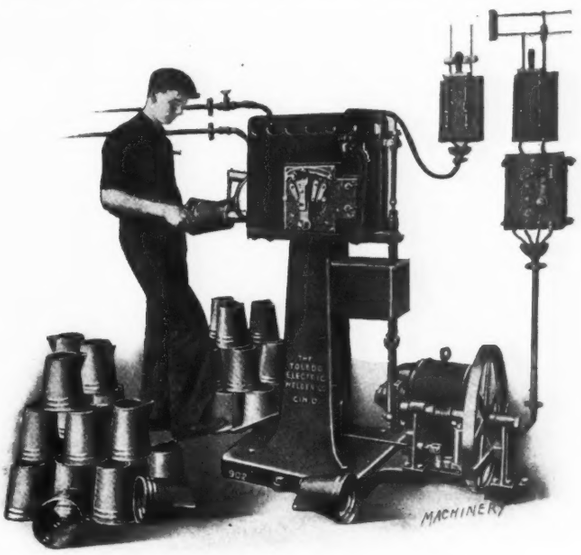


Fig. 2. Power-driven Spot Welder

jaws come together and reduce the fin or projection that is raised, thus leaving the welded portion practically the same thickness as the rest of the stock so that grinding or hammering is not necessary. At the end of this second operation the

clamping dies automatically open, after which the tire is removed and the next one is inserted. From 1800 to 2000 tires can be welded per day of 10 hours.

Alternating current is required to operate the welder, and it can be arranged for any standard voltage from 110 to 550 volts. A special transformer in the base of the welder reduces the voltage to from 3 to 5 volts, which is all that is used in the machine. This low voltage makes the machine absolutely safe, as the operator cannot get the slightest shock under any condition. A regulator is furnished to control the current, thus allowing the operator to vary the heat according to the size of stock to be welded. The dies are water cooled, and a very small amount of water is required. Adjustments are provided to vary the pressure of the welding heads, according to the size of stock to be welded.

This company has also added a new power-driven spot welder to its line. This machine is illustrated in Fig. 2, which shows an operator welding spouts on coffee pots. A small variable-speed motor furnishes the power for driving the machine, and welds are made at the rate of 80 to 150 per minute. The machine works on the same principle as the ordinary power-driven punch press. The operator presses down on a foot treadle which engages a clutch and starts the machine. When the foot pressure is released the machine stops, and when it stops the dies are open ready for the next weld. One weld or any number can be made. The welding dies move up and down like a sewing machine, as long as the treadle is held down.

When the dies are brought down on the stock the current is turned on to make the weld, and at the instant the melted metal is forced together the current is turned off. The current is controlled automatically and there is no possibility of drawing an arc and burning the stock when the die points are moved apart. The machine is easy to operate as a punch press, and there is no danger, either from the mechanical operation or the welding current. Like all welding machines, it is necessary to have a single-phase, alternating current. Where a two- or three-phase current is used, one phase of the multiphase system can be connected to the welder.

FOOTE-BURT MUD-RING AND FLUE-SHEET DRILL

The large two-head drilling machine illustrated herewith was designed primarily for drilling the mud rings and flue sheets of locomotive boilers but it is also suitable for a general line of heavy work. It is built by the Foote-Burt Co., Cleveland, Ohio. By referring to the front view, Fig. 1, it will be noted that each of the two heads is an independent and self-contained unit, thus permitting the feeds and speeds for each spindle to be regulated according to the size of the hole. The heads have an in-and-out adjustment of 8 inches on the knee, which, in combination with the 24-inch lateral adjustment of the table, makes it possible to cover a large lay-out at one setting of the work.

The saddles carrying the heads and motors are very heavy and have a four point bearing on the massive box-section cross-rail. The saddles are traversed along the rail by ratchet wrenches, and, owing to a suitable gear reduction, adjustment is easily made. The end view of the machine (Fig. 2) gives an idea of its massive construction and also shows the position of the driving motors. By mounting the motors as shown, a simple form of drive is secured. The primary drive from the motor is through a rawhide pinion and a coarse pitch spur gear to a horizontal shaft which transmits the motion through bevel and spur gearing to the spindle. The bevel gears are made of forged steel, have planed teeth and are carefully heat-treated and hardened. These gears run in extra-long bronze bushings, thus insuring alignment.

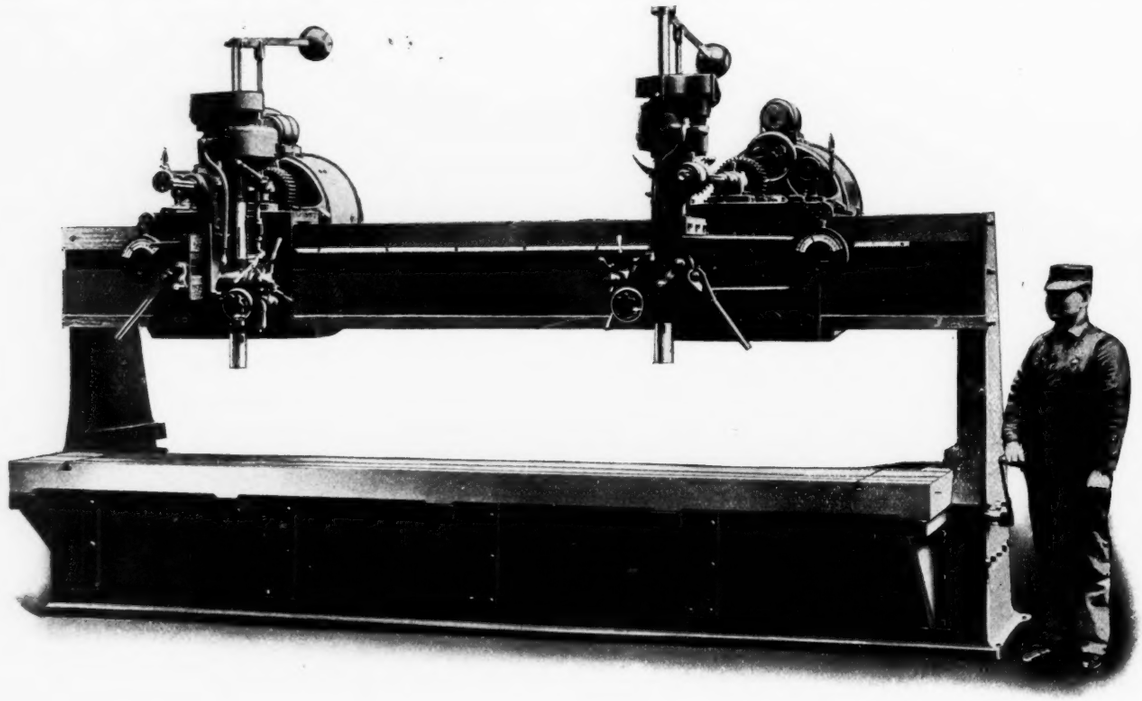


Fig. 1. Foote-Burt Mud-ring and Flue-sheet Drill with Reliance Speed Dial and Automatic Speed and Starting Control

Each spindle has an individual clutch, so that it can be started and stopped at will, without stopping the motor. With this arrangement, the motor can be adjusted for a single speed and need not be disturbed in case it is necessary to stop the spindle. The feed changes are obtained through a quick change gear device operated by a conveniently located lever. The power feed has an automatic stop, in addition to the usual hand trip and clutch, and there is a quick-return movement operated by the spider handwheel shown. The spindle and feed worms have ball thrust bearings of the company's own design. Each head is equipped with an individual oil pump and tank.

When drilling mud rings, the brackets supporting the table are removed and special mud-ring chucks are placed on the table, which is run back between the housings. The brackets are doweled in position, and can be removed and replaced readily.

The possibility of eliminating gear changes and using wide-range motors in conjunction with a direct drive is well illustrated by this equipment. Adjustable-speed, 7½-horsepower

motors of the armature-shifting type are used. These are made by the Reliance Electric & Engineering Co., and have a speed range of from 200 to 1600 R. P. M. The shifting of the armature for obtaining the speed changes is effected by a small motor which is mounted on top of the main driving motor, as shown in Fig. 2, connection being made with the shifting mechanism through a chain and sprockets. To adjust the speed, the operator simply presses the "fast" or "slow" button of a small speed control "station" conveniently located at the front of each head.

This machine is equipped with a Reliance speed dial similar in principle to the one illustrated and described in the department of New Machinery and Tools, for March, 1912. This particular dial has two scales, the upper one of which is graduated to show the cutting speeds in feet per minute, and the lower one, the various sizes of drills. The dial is first set for the cutting speed desired, by turning a small knurl in front of the case; the speed of the motor is then adjusted until the pointer is opposite the size drill to be used.

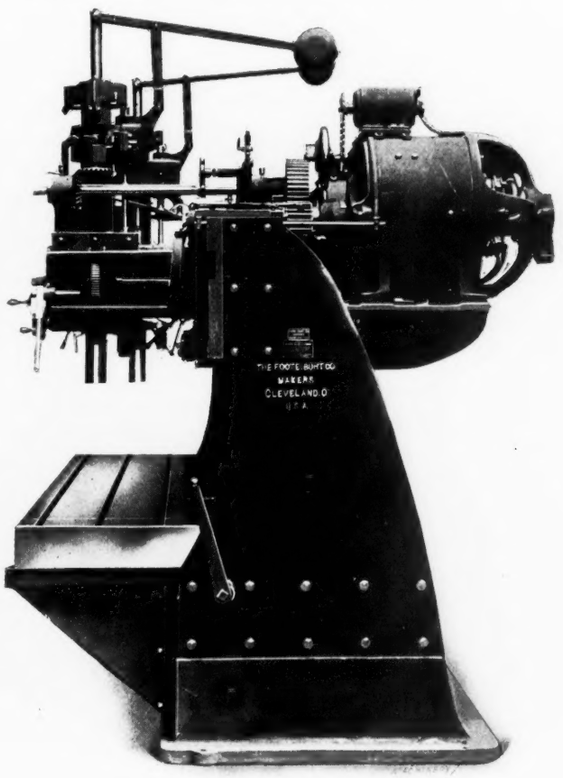


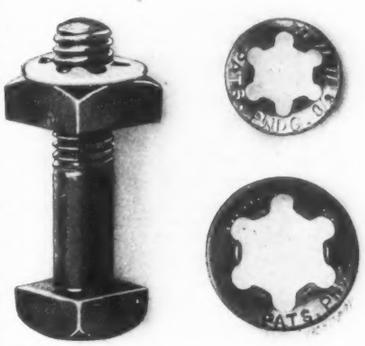
Fig. 2. End View of the Foote-Burt Machine

The starting and stopping of the motor is controlled through automatic starters operated by push buttons. These starters are located on each head close to the speed control station. This combination of automatic starting and speed control enables the operator to give his entire attention to the work in hand.

This machine has a width between the housings of 14 feet 4 inches, and the maximum distance from the end of the spindle to the table is 21½ inches. There is a 12-inch power feed and three feed changes varying from 0.006 to 0.020 inch. The maximum and minimum center distances between the spindles are, respectively, 10 feet and 18 inches. The spindle speeds range from 37 to 347 R. P. M. The table has a working surface of 14 feet 4 inches by 24 inches, and the weight of the machine is 28,000 pounds.

WORTH WEDGE-WASHERS

There are many different ways of locking a nut on a bolt, but comparatively few of the innumerable devices designed for this purpose have come into general use. Either the expense of manufacturing the device has been prohibitive, or its application to a bolt or nut has required too much time. The Steel Specialties Co., Boston, Mass., has placed on the market a very simple device which, it is claimed, effectively prevents a nut from jarring off a bolt. This nut fastener is in the form of a washer which, as shown by the illustration, has a scalloped inner edge with projections or prongs which point outward before the washer is applied to a bolt. After the washer is placed over a bolt, it is straightened or flattened by driving it down with a punch or larger size nut, which causes the prongs to wedge tightly between the threads of the bolt and the body of the nut. A washer has been applied in this way to the bolt shown in the illustration. After a washer is in place, the nut can be screwed off with a wrench, but it will not jar off. The "wedge-washer" can be removed easily by severing one side with a chisel, and it is said to leave the thread uninjured.



Wedge-washers to prevent Nuts from Jarring Off

NEW BRITAIN PORTABLE STEEL TOOL-RACK

The portable tool-rack or work-stand shown herewith is made of steel instead of cast iron, which gives a light but strong construction. The corners of the drawn-steel trays are rounded to facilitate cleaning, and the trays are stiffened by return flanges on the edges, which also contain the corner braces. The legs are screwed into the braces attached to the upper tray and pass through the lower ones. The lower pans can be fastened to the legs at any desired height. In all trays, the holes for the brace rivets or legs are at the top edge of the pan, so that oil cannot leak through them.

These tool-racks are made in two sizes. The size illustrated is 26 by 32 inches, and there is a smaller size measuring 20 by 26 inches. The casters have ball-bearing swivels and the balls are in a retainer cage and can be handled as a unit. These racks are manufactured by the New Britain Machine Co., New Britain, Conn.

Tool-rack or Work Stand made of Steel

NEW MACHINERY AND TOOLS NOTES

Boring Tool. R. M. Clough, Tolland, Conn. Adjustable boring tool for sizing holes either to standard diameters or slightly under, when a finishing reamer is to be used. This tool has blades which are clamped in position with a square-ended wrench.

Tool Grinder. J. G. Blount Co., Everett, Mass. Wet tool grinder similar in construction to machines previously built by this company, but considerably heavier. The bearings are self-oiling, and the wheel is 30 by 3 inches. The machine is equipped with a vertical, centrifugal pump.

Toolpost Grinder. American Electric Tool Co., West Newton, Mass. Portable electric grinder carrying a 6 by ⅜-inch wheel, which operates at a speed of 3500 R. P. M. This grinder can be applied to a lathe toolpost and is applicable to the grinding of lathe centers, milling cutters, etc.

Tool Grinders. Northampton Emery Wheel Co., Leeds, Mass. Wet tool grinders having wheels 16, 20 and 24 inches in diameter, respectively. Water is thrown up against the wheel from a tank in the base, by an endless chain, and the quantity can be varied by a conveniently located lever.

Die Milling Machine. Harrington Machine Co., Erie, Pa. The spindle of this machine is at right-angles to the worktable, and clearance in the dies is obtained by using angular mills. Both the table and spindle can be tilted to an angle either to the right or left to secure better light or to suit the convenience of the operator.

Riveting Machine. C. W. Meadowcroft, Sr., 4702 Large St., (Frankford), Philadelphia, Pa. Rotary riveting machine built in the following styles: As a bench machine with foot control, as a column foot-lever type, and as a dial feed machine, the latter taking the place of the foot-lever designed for certain classes of work.

Electric Furnace. Multiple Unit Electric Co., 136 Liberty St., New York. Electric muffle-furnace with special controller built in the furnace case. Temperatures varying from 200 to 1800 degrees F. can be maintained indefinitely, and the furnace will operate on a 100 or 220 direct or alternating-current circuit, but cannot be used with both circuits, as the controller is built with reference to the voltage.

Band Finishing Machine. Gardner Machine Co., Beloit, Wis. Motor-driven band finishing machine, the wheels of which are mounted directly on the armature shaft. Adjustable, cast-iron dust-hoods nearly enclose the wheels, and there is an opening at the bottom for exhaust connection. The band wheel is so arranged that the band is kept taut under a constant spring tension. This machine is also made for a belt drive.

Tube Cleaner. Joseph T. Ryerson & Son, Chicago, Ill. Tube-cleaning attachment designed to be used in connection with this company's tube-cutting machine. The principal parts are a friction wheel, and adjustable twin-roller cleaning burrs which are built of hardened serrated steel disks. These cleaning burrs are assembled in a unit, which is readily interchanged with the roller tube support employed when the machine is used for cutting tubes.

Cylinder Boring Machine. Newton Machine Tool Works, Inc., Philadelphia, Pa. Locomotive cylinder and valve chamber boring and facing machine, so designed that the valve chamber can be bored without resetting the work. The table has a vertical adjustment and the spindle, which is 7 inches in diameter, has a rapid power traverse in either direction, in addition to the hand adjustment. The minimum distance between the center of the spindle and the top of the table is 16 inches and the maximum, 40 inches.

Gear-cutting Machine. E. J. Flather Mfg. Co., Nashua, N. H. Forty-inch automatic gear-cutting machine arranged with a bevel gear attachment and equipped with a motor drive. The power is transmitted through an endless leather belt, the tension of which is varied by adjusting the base of the motor. The indexing mechanism is enclosed and mounted in a detachable bracket. The machine is built on the unit system, and the indexing, feed, and speed mechanisms, as well as other parts, are finished and tested before being assembled.

Gang Drill. W. F. & John Barnes Co., 231 Ruby St., Rockford, Ill. 20-inch, sliding-head gang drill made with from two to six spindles. This machine can be equipped with either a plain lever feed, a combined lever and worm feed, or a self-feed and automatic stop. The automatic stop mechanism is so designed that it can be set to disengage the worm from the worm-gearing, thus permitting the drill spindle to be returned quickly, or it can be arranged to disengage the miter feed gears, which stops the feed but leaves the worm-gearing in mesh for accurate facing operations.

Drilling Machine. Langelier Mfg. Co., Providence, R. I. Special drilling machine intended for drilling and countersinking two holes on the opposite sides of jewelry beads. The machine is also applicable to many other uses. It is equipped with two vertical spindles which are opposed, one being below and the other above the part to be drilled. These spindles are actuated through rack and pinions and both move toward the work simultaneously. To cases where it is necessary to drill two holes on the same axis and part way through the work, this machine is especially adapted.

Turret Drilling Machine. Turner Machine Co., Danbury, Conn. Four-spindle turret drilling machine intended for work requiring more than one operation at one setting. The spindles are mounted in a vertical turret and are driven through spur gears. By means of an indexing device, any one of the four spindles can be quickly located and locked in the operating position. The maximum distance from the operating spindle to the table is 28 inches. The over-all height is 6 feet 2 inches, and the weight 700 pounds. This machine is also built in other styles and sizes to suit different classes of work.

Loxograph. The Loxograph Instrument Co., Wilmington, Del. The loxograph is a triangular straightedge as well as a true 45-degree angle, and the ruling edges are supported out of contact with the paper by hardened steel knife-edged wheels. As these wheels do not pick up ink, the instrument can be moved over wet ink lines without blurring or smearing them, so that the work of making ink drawings can proceed rapidly, as it is unnecessary to wait for the ink to dry. Flooding is also impossible, even though the ink wets the ruling edges. The loxograph is made in 5¾- and 10-inch sizes, respectively. The instrument has been thoroughly tested, and is said to effect a considerable saving in time.

Tool-Grinding Machine. Brown & Sharpe Mfg. Co., Providence, R. I. Universal and tool-grinding machine which will take work up to 18 inches in length and swing 12 inches. It is especially adapted to the grinding of milling cutters, straight or taper reamers, etc. This machine can also be used for straight or taper cylindrical grinding, and, by means of attachments, internal and surface grinding can also be done. The base and column are cast in one piece, thus giving a rigid support for the wheel spindle. The spindle head has a traverse adjustment of 1½ inch, a vertical adjustment of 4 inches, and a radial movement to any position. The sliding table is operated by a crank at the front of the saddle, and can be swiveled to 45 degrees either side of the central position. Sixteen changes of work speeds are obtained through a multiple, friction-disk speed mechanism. Provision is made for wet grinding.

* * *

THE TRAINING OF DRAFTSMEN

In a paper read before the American Society of Engineer Draftsmen, Mr. F. G. Higbee gave a brief summary of the particularly important subjects in which a draftsman ought to be proficient in order to fill his position in life to the best advantage to himself and his employer. Primarily, a draftsman must know how to draw; that is, he must have mastered the technique of drawing and must be able to execute a neat and clear drawing with legible letters and dimensions. This, of course, is merely a foundation upon which to build. A good draftsman must have a good grasp of shop methods and should have a fair conception, both by observation and actual practice, of patternmaking, foundry practice, forging and machining operations. Next, a good draftsman and designer must have a grasp of the theoretical principles of mechanisms. Pulleys, belting, gearing, mechanical movements, fastenings, bearings, and lubrication are the elements which he should take up in turn and study and discuss with those who could give him practical pointers.

It is also necessary in order to be a fair draftsman and designer to have some knowledge of the properties of the various materials used in engineering work and machine construction. He must also have a fair knowledge of the mathematical and mechanical principles involved in calculations of the strength of materials. Mathematics is ever an important subject and one on which many draftsmen fall short. The so-called higher mathematics are, perhaps, seldom required, but trigonometry and logarithms and a fair portion of plane and solid geometry will never fail to prove useful. The good machine designer also needs an understanding of the principles of physics and chemistry; the practical application of electricity and magnetism; the laws of vapors and gases; hydrostatics, and in general, of the fundamental physical laws which are the foundation of all engineering work. Last, but not least, the study of English should never be overlooked or neglected by one who expects to hold anything but a subordinate position. Its proper use is essential to every man who would win the respect and confidence of his associates and superiors, and no training in engineering is complete without a knowledge of how to convey ideas correctly in written form.

This outline gives the necessary foundation for any draftsman who hopes to be able to advance, and it provides a foundation upon which any man may build, no matter to what aspirations his ambition may have inspired him.

DRILLING MACHINES FOR PANAMA CANAL GATES

Sixteen electrically operated machines of special construction are being used for drilling and reaming rivet holes in

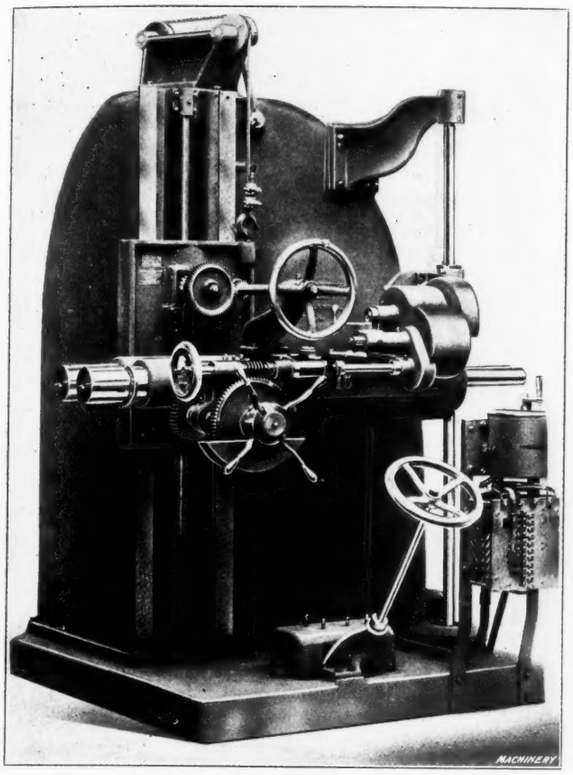


Fig. 1. Foote-Burt Special Drilling Machine for Canal Gates

the enormous lock gates of the Panama Canal. Each of these machines weighs about six tons. They are mounted on broad adjustable scaffolds which are suspended on chains attached to

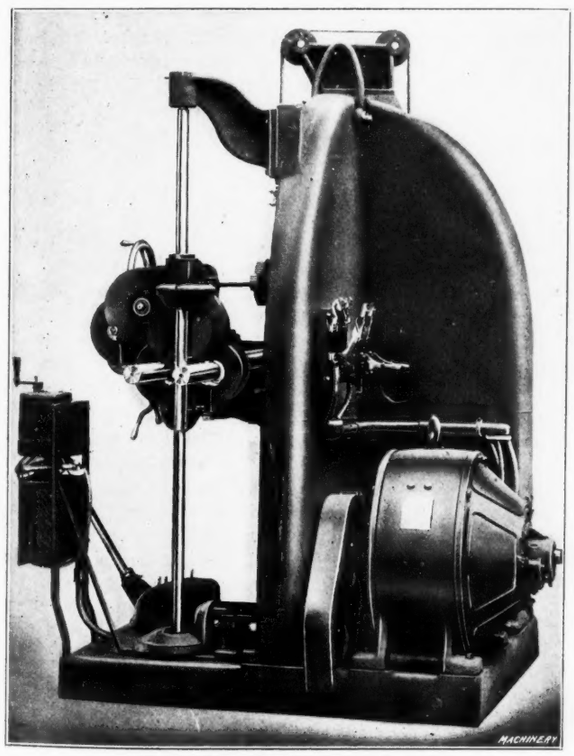


Fig. 2. Side View showing Motor Drive

brackets on top of the gate, as shown in Fig. 3. On each scaffold there is a standard gage track along which the machine is moved for drilling the horizontal rows of rivet holes. This movement is effected by the inclined handwheel seen in Fig. 1, which is a front view of one of the machines. This handwheel operates through a train of gears, and the adjustment can readily by made as roller bearings are used.

All of the controlling mechanism is centrally located as the illustration shows. The horizontal shaft and handwheel above the spindles, actuates, through suitable reduction gearing, a screw which raises and lowers the drilling head. This head is counterbalanced so that vertical adjustment is easily made. The spindles have a quick-return movement effected by any one of the four levers of the spider-wheel shown.

Each machine has four changes of power feed which are obtained through a quick change gear mechanism. The length of the power feed is 16 inches and either of the spindles can be fed independently. The clutch lever for engaging either spindle is located just above the No. 15 seen on the head of the machine, and the feed changing lever is just above this clutch lever. There are nine speeds varying from a very slow speed for heavy drilling, to very high speeds for lighter work. The

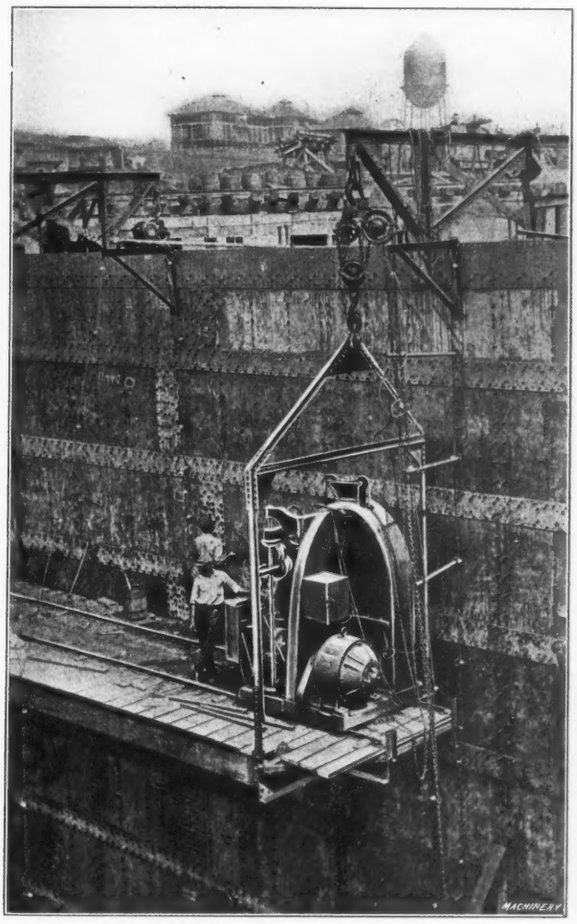


Fig. 3. Drilling Machine on Scaffold for Drilling Rivet Holes in Panama Canal Lock Gates

spindles are arranged to suit the uniform spacing of the rivet holes in the lock gates. During a test made at Gatun, one of the machines drilled 1 1-16 holes through 1-inch plates in four seconds, or at the rate of 15 inches per minute.

These machines are driven by Westinghouse direct-current, adjustable-speed, shunt-wound motors rated at 10 horsepower. The motor is mounted directly on the base, as shown in Fig. 2, and connection is made with the spindles through the gearing shafts, as shown.

These machines were placed in operation in February of this year, on the main gates at Gatun, and they are to be used on all the gates in the three locks. They were designed and built by the Foote-Burt Co., Cleveland, Ohio, especially for use on the Panama Canal.

* * *

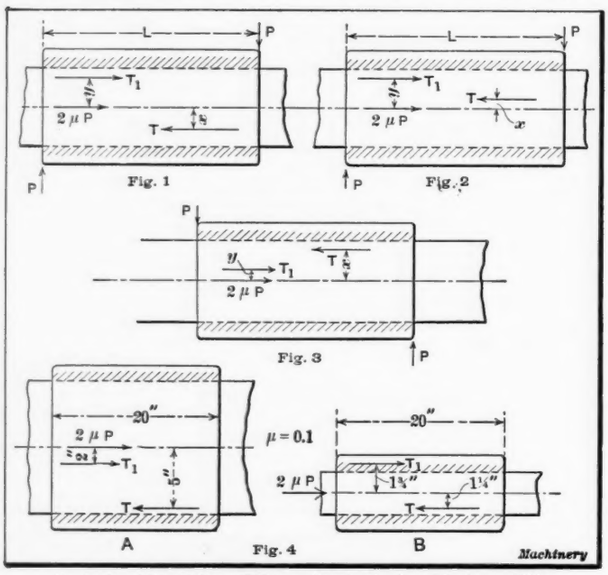
The third and last installment of "Watch Movement Manufacture" will appear in a future number.

THE ADVANTAGE OF THE NARROW GUIDE

By JOSEPH JEWSBURY*

The recent articles on the "narrow guide" which have appeared in MACHINERY have called attention to facts which have not been recognized hitherto by many designers of machinery. The writer, in common with others, had instinctively accepted as an axiom that the narrow guide did reduce "cross-wind," and had never attempted a mathematical analysis of the conditions. In the catalogues of some leading makers of machine tools, it is stated that one of the advantages of the narrow guide is that it reduces "cross-wind."

In the present article the writer intends to deal with the question of the relative locations of the guide center, feeding force, and the main resistance. This will, in a way, supplement the analysis given by Mr. H. T. Millar in the May number of MACHINERY, engineering edition. Five arrangements of positions of guide center line, feeding force, and resistance of cut are possible. Three of these are indicated in Figs. 1, 2 and 3.



Analysis of the Action of Forces involved when Moving a Slide against the Resistance of a Cut

In Fig. 1, the guide center line is located between the feeding force T and the resistance T_1. Fig. 2 shows T and T_1 on the same side of the guide center, T_1 having the greater eccentricity, and in Fig. 3, T acts at a greater distance from the guide center than T_1 and on the same side of it. The two remaining conditions are when the feeding force is in the same line as the cutting resistance, either eccentric to the guide center or on the same line.

Using the notation shown in the accompanying engraving, we have from Fig. 1:

$$P L = T x + T_1 y \qquad (1)$$

$$2 \mu P = T - T_1$$

$$\text{Hence, } P = \frac{T - T_1}{2 \mu} \qquad (2)$$

From (1) and (2):

$$\frac{L (T - T_1)}{2 \mu} = T x + T_1 y$$

$$T = \frac{T_1 (L + 2 \mu y)}{L - 2 \mu x} \qquad (3)$$

In Fig. 2, $P L = T_1 y - T x$, and by proceeding as before, we find:

$$T = \frac{T_1 (L + 2 \mu y)}{L + 2 \mu x} \qquad (4)$$

Similarly for Fig. 3, $P L = T x - T_1 y$, and

$$T = \frac{T_1 (L - 2 \mu y)}{L - 2 \mu x} \qquad (5)$$

In the other two cases T is equal to T_1, neglecting other resistances.

Comparing the results (3) and (4), and (3) and (5), it is obvious that, with the same values for L, T, x and y, the feeding force is greatest with the arrangement shown in Fig. 1. The dimensions of x and y determine whether the arrangement in Fig. 2 or Fig. 3 is more efficient. As an example, assume that $T_1 = 2000$ pounds, $L = 20$ inches, $x = 4$ inches, $y = 6$ inches, and $\mu = 0.1$.

In Fig. 1, Equation (3),

$$T = \frac{2000 (20 + 2 \times 0.1 \times 6)}{20 - 2 \times 0.1 \times 4} = 2208 \text{ pounds.}$$

In Fig. 2, Equation (4),

$$T = \frac{2000 (20 + 2 \times 0.1 \times 6)}{20 + 2 \times 0.1 \times 4} = 2038 \text{ pounds.}$$

Hence, the feeding force is 170 pounds greater in the former case.

From (3) and (4) we find that the feeding force in Fig. 1 is to that in Fig. 2 as $L + 2 \mu x$ is to $L - 2 \mu x$. From (3) and (5) we find that the feeding force of Fig. 1 is to that of Fig. 3 as $L + 2 \mu y$ is to $L - 2 \mu y$. This shows that it is best, whenever possible, to have the feeding force act on the same side of the guide center as the cutting resistance. As pointed out in the article on this subject in the May number, the advantages of the narrow guide are dependent mainly on its correct location. That this is true, and that this is in fact the deciding factor, is proved by the expressions (3), (4) and (5), and can be strikingly illustrated by an example. Comparing the relative values of the feeding forces in cases *A* and *B*, Fig. 4, it will be found that for this particular case no advantage is gained by the adoption of the narrow guide, owing to the unfavorable location of the feeding force and the resistance.

Case A, Equation (5), $T = \frac{T_1 (20 - 2 \times 0.1 \times 2)}{20 - 2 \times 0.1 \times 5} = 1.03\, T_1$

Case B, Equation (3), $T = \frac{T_1 (20 + 2 \times 0.1 \times 1.75)}{20 - 2 \times 0.1 \times 1.25} = 1.03\, T_1$

Hence, T is practically the same in both cases.

Two well-known examples from practice may be pointed out where the feeding force acts on the same side of the guide center as the main resistance, *viz.:* the cutter slide of the Brown & Sharpe gear cutter illustrated in the article referred to in the May number of MACHINERY, and the side shaper of English design when arranged with a narrow guide.

* * *

NEW ELECTROPLATING PROCESS

Consul Horace Lee Washington, of Liverpool, England, reports that a new electroplating process has recently been developed by two Italian chemists. A description of this process recently appeared in *Chambers Journal.* The process is creating considerable interest, as it comprises a means of depositing metals of any character upon any insoluble surface by electrical energy. It is claimed that china, wood, glass, celluloid, paper and other substances which have hitherto been regarded as beyond the electroplater's art can be coated as easily as metals generally electroplated. The plating enters the fabric of the material so treated and becomes practically an integral part of it. If an attempt, for instance, is made to chip the plating from a glass vase the glass will come away with the metal coating. When plating china, the article must be in its unglazed condition, and glass which is to be treated must first be roughened by sandblasting to remove the polish, so as to enable the metal to secure a firm grip. The process, which is known as the Marino process, is also of considerable hygienic value in the household, where many articles may now be used plated with suitable metals. The possibility of being able to deposit a coating upon aluminum, for example, thus saving it from oxidation, will popularize the use of this metal in the home and in many industries where it is now excluded on account of the fact that it rapidly corrodes in the presence of acids.

* Address: 13 Winsted Rd., Gravelly Hill, Birmingham, England.

M. C. B. AND A. R. M. M. ASSOCIATIONS CONVENTIONS

The forty-sixth annual convention of the Master Car Builders Association and the forty-fifth annual convention of the American Railway Master Mechanics Association were held at Atlantic City, N. J., June 12 to 19, inclusive. The Master Car Builders convention was held June 12, 13 and 14, and the Railway Master Mechanics convention June 17, 18 and 19, on Young's new pier.

The technical program of the Master Car Builders Association included the following papers and discussions:

June 12—"Train Brake and Signal Equipment"; "Brake Shoe Equipment"; "Car Wheels."

June 13—Discussion of reports on "Safety Appliances"; "Rules of Interchange"; "Prices for Labor and Materials"; "Rules for Loading Materials"; "Damage to Freight Equipment by Unloading Machines"; "Overhead Inspection"; "Coupler and Draft Equipment"; "Car Trucks"; "Springs for Car Trucks"; "Train Lighting and Equipment."

June 14—Discussion of reports on "Train Pipe and Connections for Steam Heat"; "Tank Cars"; "Specifications for Tests of Steel Truck Sides and Bolsters"; "Capacity Marking of Cars"; "Lettering Cars."

The following officers were elected for the Master Car Builders Association:

President, C. E. Fuller, Union Pacific Ry.
First vice-president, M. K. Barnum, Illinois Central R. R.
Second vice-president, D. F. Crawford, Pennsylvania Lines.
Third vice-president, D. R. MacBain, L. S. & M. S. Ry.
Treasurer, John S. Lentz, Lehigh Valley R. R.
Executive Committee—R. E. Smith, Atlantic Coast Line; C. E. Chambers, Central R. R. of New Jersey; and Henry LaRue, Chicago, Rock Island & Pacific R. R.

The program of the American Railway Master Mechanics convention was as follows:

June 17—Discussion of reports on "Mechanical Stokers"; "Revision of Standards"; "Specifications for Cast Steel"; "Locomotive Frames."

June 18—Discussion of reports on "Main and Side Rods"; "Safety Valves"; "Safety Appliances"; "Design, Construction and Maintenance of Locomotive Boilers"; "Contour of Tires"; individual paper on "Increased Power Obtained with Superheat as Compared with the Maximum Power Obtained with Saturated Steam," by Prof. C. H. Benjamin and Prof. L. E. Endsley; "Steel Tires."

"June 19—Discussion of reports on "Flange Lubrication"; "Minimum Requirements for Headlights"; "Standardization of Tinware"; "Maintenance of Superheated Locomotives"; "Engine Tender Wheels."

The following officers were elected for the American Railway Master Mechanics Association:

President, D. F. Crawford, Pennsylvania Lines.
First vice-president, T. Rumney, C. R. I. & P. R. R.
Second vice-president, D. R. MacBain, L. S. & M. S. Ry.
Third vice-president, F. F. Gaines, Central of Georgia Ry.
Executive Committee—G. W. Wildin, N. Y., N. H. & H. R. R.; C. F. Giles, L. & N. Ry.; and William Schlafge, Erie R. R.

The Railway Supply Manufacturers Association holds an annual exposition of railway car and locomotive parts, supplies, apparatus, etc., on the pier simultaneously with the conventions. The exhibit this year was larger than ever before, the space having been increased by extending the pier, thus making 7400 square feet additional space available, and increasing the total area to 83,500 square feet. Among the manufacturers exhibiting were the following:

Ajax Mfg. Co., Cleveland, Ohio. Scrap reclaiming rolls and forgings.

American Infusion Steel Process Co., New York. Compound for casehardening and converting low-grade steel into high-grade steel.

American Tool Works Co., Cincinnati, Ohio. Motor-driven machine tools comprising 24-inch geared head lathe, 16-inch relieving lathe, 2-foot geared radial drill, 6-foot plain radial drill, 16-inch shaper and 24-inch shaper.

American Vanadium Co., Pittsburg, Pa. Vanadium steel, iron, brass and bronze locomotive parts, vanadium steel forgings, etc.

Baker Bros., Toledo, Ohio. Automatic drilling machine.

Baush Machine Tool Co., Bethlehem, Pa. Hydro-pneumatic radial drill.

Bullard Machine Tool Co., Bridgeport, Conn. Forty-two-inch vertical turret lathe.

Carborundum Co., Niagara Falls, N. Y. Carborundum and Aloxite grinding wheels.

Chisholm & Moore Mfg. Co., Cleveland, Ohio. Chain hoists, and I-beam trolleys.

Davis Boring Tool Co., St. Louis, Mo. Line of Davis expansion boring tools.

Davis-Bournonville Co., New York. Oxy-acetylene welding and cutting apparatus, including the "oxygraph," a device working on the pantograph principle.

Duff Mfg. Co., Pittsburg, Pa. Track jacks and screw jacks.

Gilbert & Barker Mfg. Co., Springfield, Mass. Apparatus for storing and handling oils.

Goldschmidt Thermit Co., New York. Thermit products and exhibits showing the application of the thermit process for welding.

Gould & Eberhardt, Newark, N. J. Twenty-four-inch shaper and model showing construction of sixteen-inch shaper.

Edwin Harrington Son & Co., Inc., Philadelphia, Pa. I-beam trolleys and spur geared and screw hoists.

Higley Machine Co., New York. Cold metal saw.

International Oxygen Co., New York. I. O. C. generators for producing oxygen and hydrogen, etc.

Landis Machine Co., Waynesboro, Pa. Double head bolt cutters.

Lucas Machine Tool Co., Cleveland, Ohio. Precision horizontal, boring, drilling and milling machine.

Manning, Maxwell & Moore, Inc., New York. Hendey lathes, Gridley automatic machines, Cincinnati gear cutters, Cincinnati crank planers, Reed engine lathes, National Co.'s forging and heading machines, etc.

Newton Machine Tool Works, Philadelphia, Pa. Cold saw cutting-off machine of the internal type.

Niles-Bement-Pond Co., New York. Niles new model car wheel boring machine and Pond reversing motor drive planer.

Norton Co., Worcester, Mass. Grinding wheels and floor grinders.

Norton Grinding Co., Worcester, Mass. Ground car axles and car wheels.

Oxweld Acetylene Co., Chicago, Ill. Oxy-acetylene and oxy-hydric welding apparatus.

C. F. Pease Co., Chicago, Ill. Automatic blueprinting and washing machine.

Wm. Sellers & Co., Inc., Philadelphia, Pa. Locomotive injectors, parts of high power car wheel lathes, etc.

Standard Roller Bearing Co., Philadelphia, Pa. Roller bearings, car journal boxes and other anti-friction bearings.

Tabor Mfg. Co., Philadelphia, Pa. Inserted tooth saws.

Van Dorn & Dutton Co., Cleveland, Ohio.. Portable electric drills and reamers.

Vixen Tool Co., Philadelphia, Pa. Vixen files and machine for testing files.

Warner & Swasey Co., Cleveland, Ohio. Hollow hexagon turret lathe.

Watson-Stillman Co., New York. Hydraulic jacks.

Wilmarth & Morman Co., Grand Rapids, Mich. Surface grinders, lathe center grinders, drill grinders, etc.

Yale & Towne Mfg. Co., New York. Chain blocks, electric hoists, trolleys, locks, etc.

* * *

SPRING MEETING OF THE A. S. M. E.

The Spring meeting of the American Society of Mechanical Engineers was held in Cleveland, Ohio, May 28-31. Past president Ambrose Swasey, chairman of the executive committee, opened the meeting with a speech of welcome. Dr. A. C. Humphreys, president of the society, spoke on the economic relations of the engineer and society. The professional sessions were held in the Chamber of Commerce, as was also the membership reunion and informal reception. The registration of members of all grades was the largest of any Spring meeting in the history of the society, being nearly 600. The technical program included the following papers and lecture:

"A New Analysis of the Cylinder Performance of Reciprocating Engines," J. Paul Clayton.

"Equipment of a Modern Flour Mill on a Gradual Reduction System," John F. Harrison and W. W. Nichols.

"Design and Mechanical Features of the California Gold Dredge," Robert E. Cranston.

"Problems in Natural Gas Engineering," Thomas R. Weymouth.

"Sound Waves—How to Photograph Them and What They Mean," Dr. Dayton C. Miller of the Case School of Applied Science.

"New Processes for Chilling Cast Iron," Thomas D. West.

"Strength of Steel Tubes, Pipes and Cylinders Under Internal Flume Pressure," Reid T. Stewart.

"On the Control of Surges in Water Conduits," W. F. Durand.

"Speed Regulation in Hydro-electric Plants," Wm. F. Uhl.

"The Present State of Development of Large Steam Turbines," A. G. Christie.

"A Discussion of Certain Thermal Properties of Steam," G. A. Goodenough.

"The Reduction in Temperature of Condensing Water Reservoirs Due to Cooling Effect of Air and Evaporation," W. B. Ruggles.

"Results of Tests on the Discharge Capacity of Safety Valves," E. F. Miller and A. B. Carhart.

An informal reception for the members was held at the home of Mr. and Mrs. Ambrose Swasey, Tuesday afternoon, May 28, and a reception and dance at the Colonial Club Thursday evening, May 30.

The plants of Warner & Swasey Co., Brown Hoisting Machinery Co., Winton Motor Co., Peerless Motor Car Co., National-Acme Mfg. Co., White Co., American Steel & Wire Co., Wellman-Seaver-Morgan Co., Akron; Goodrich Rubber Co., and the Diamond Match Co., at Barberton, were open to members.

* * *

AEROPLANE EXPOSITION IN BERLIN

An International Aeroplane Exposition was held in Berlin, Germany, during the month of April. The most interesting fact brought out during the exposition was that so large a number of firms exist in Germany that are directly interested in the aeroplane industry. At the exposition there were 176 exhibitors in all, of which twenty-two were firms exhibiting aeroplanes. There are twenty-seven German firms building aeroplanes exclusively, and twelve more constructing aeroplanes in addition to other products. Many of these aeroplane factories are, of course, very small. Several, however, are organized wth a considerable capitalization—for example, one company is capitalized at $375,000, another at $150,000, another at $62,500, while three are capitalized at $25,000 each. There are between 400 and 500 aeroplanes in use at the present time in Germany. Of the forty aeroplanes shown at the exposition, thirty were monoplanes, nine biplanes, and one a triplane. The proportion of the various types, however, is somewhat misleading as regards the relative popularity of the various types, as the biplanes were exhibited by several of the German firms who had been most successful, while many of the monoplanes shown were experiments by unknown firms. For military purposes, and in general when the greatest speed is not essential, the biplane seems to have proved most satisfactory in Germany.

In general, the designs followed closely the various French types, and there was an absence of freak machines such as are generally seen at expositions of this kind. Consul General A. M. Thackara of Berlin, from whose report to the Department of Commerce and Labor the facts above are abstracted, states that, at the present time, America has little to learn from Germany as regards actual designs of aeroplanes, as the ideas in prominence at the Berlin exposition were largely of French and American origin. This condition, he states, will, however, probably not obtain much longer, as the aeroplane problem is now being attacked in Germany from every side both by the aviator in the field and the scientist in the laboratory.

The most powerful aeroplane exhibited was the Boris Loutzkoy monoplane which was fitted with two 100-horsepower "Argus" motors, each driving an independent propeller, revolving around the same axis. With both motors, the aeroplane, it is claimed, can attain a speed of ninety-three miles an hour. The machine can fly, however, with either motor alone. The weight, with pilot, one passenger, and supplies for a six-hours' flight is about 3000 pounds. The width of the machine is 62 feet, the length about 50 feet and the supporting surface, 560 square feet. The "Argus" motor used in this aeroplane is of the four-cylinder type, making 1250 revolutions per minute, and having a weight of 288 pounds or slightly less than 3 pounds per horsepower. Hilz of Dusseldorf exhibited a motor of 120 horsepower, the weight of which was only 2.2 pounds per horsepower.

* * *

PERSONALS

Frank Salomon, president of the Otto Gas Engine Works, Philadelphia, Pa., will sail on the *Cincinnati* July 4 for a six weeks' trip in Germany.

Ehrich Krell, vice-president of the Otto Gas Engine Works, Philadelphia, Pa., will return July 1 from a three months' business trip to Germany and England.

C. E. Coolidge, Western representative of the Niles-Bement-Pond Co., has resigned to take charge of the manufacturing equipment in the various plants of the U. S. Motor Co.

Frederick J. Benjamin, advertising manager of the Pawling & Harnischfeger Co., Milwaukee, Wis., has resigned to become advertising manager of the *Iron Trade Review*, Cleveland, Ohio.

W. H. Shafer, for several years superintendent of the Cincinnati-Bickford Tool Co., Cincinnati, Ohio, has resigned to take the position of general manager of the Rivett Lathe Mfg. Co., Boston, Mass.

Charles A. Moore, president of Manning, Maxwell & Moore, Inc., New York, has returned from Europe, improved in health, after an absence of nearly two years, and has resumed attention to business.

John Johannigman, for the past ten years secretary of the Oesterlein Machine Co., Cincinnati, Ohio, resigned his position April 15. Mr. Johannigman intends to enter the machine tool manufacturing business.

H. Cadwallader, Jr., recently with the Isthmian Canal Commission at Panama, is now efficiency engineer with the Continental Motor Mfg. Co., of Muskegon and Detroit, Mich., installing the Taylor planning system.

Phil A. La Brie, formerly with the Gisholt Machine Co., Madison, Wis., has taken a position as salesman for New England with the Fitchburg Machine Works, Fitchburg, Mass., manufacturers of "Lo-swing" lathes.

J. E. Fries, engineer with the Crocker-Wheeler Co., Ampere, N. J., has been transferred to the San Francisco office as Pacific Coast engineer, where he will be able to render prompter service to the rapidly growing business of the company on the Pacific Coast.

Clarence A. Hills, who was lately made superintendent of the Abbott-Detroit Motor Co., Detroit, Mich., was presented by the employes of the Hupmobile Co., with whom he had been associated for the past two years, with a gold watch and diamond stickpin upon leaving to take his new position.

Dwight N. Lane has been made superintendent of the works of the Bantam Anti-Friction Co., Bantam, Conn. Mr. Lane, who was connected for ten years with the New Departure Mfg. Co., Bristol, Conn., is well equipped with long shop experience in connection with the manufacture of ball bearings for his new position.

Marion A. Morris has been appointed superintendent of the J. H. Sessions & Sons Co.'s plant at Bristol, Conn., succeeding Mr. Frank Garrigus, resigned. Mr. Morris was formerly connected with the Scovill Mfg. Co., and was superintendent for the Blake & Johnson Mfg. Co., from which position he recently resigned.

Joseph V. Woodworth, consulting engineer at the New York office of the Taft-Peirce Mfg. Co., Woonsocket, R. I., has resigned, and taken the position of consulting engineer and New York representative of the Boston Pressed Metal Co., Worcester, Mass., with offices in the Tribune Building, 154 Nassau St., New York.

J. P. Thompson, who has been employed as general superintendent of the Van Norman Machine Tool Co., Springfield, Mass. (formerly Waltham Watch Tool Co.), assumed his duties June 5. Mr. Thompsor was until lately general superintendent of the Cameron Steam Pump Co., New York, and formerly was with the Pond Machine Tool Co., Plainfield, N. J.

* * *

OBITUARIES

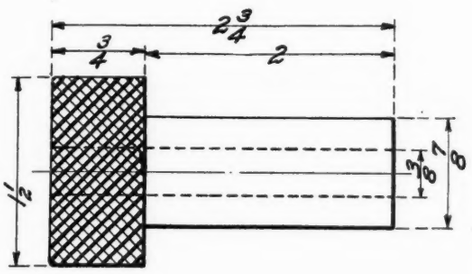
Gilbert Hart, inventor and patentee of safety emery wheels, in the manufacture of which he made a fortune, died May 31 in Detroit, Mich., aged eighty-four years.

Col. Francis A. Walker, the oldest employe of the E. & T. Fairbanks Co., St. Johnsbury, Vt., died April 26, aged eighty-seven years. Col. Walker entered the employ of the company at the age of twenty to learn the molders' trade, and for sixty-two years was a foreman.

Valdemar F. Lassoe died May 22 at his home, 83 Decatur St., Brooklyn, N. Y., aged seventy-six years. He was born in Copenhagen, Denmark, where he received an engineering education, and came to this country at the age of twenty-four. He was associated with Capt. John Ericsson in designing the *Monitor*, and subsequently worked with him for twenty-eight years. After Mr. Ericsson's death he became consulting engineer for the American Hawaiian Steamship Co., for which he designed twenty-eight steamships. He was also, for eighteen years, consulting engineer for the North German Lloyd Co., and was the originator of the system now employed for using oil as fuel on steamships. He was a frequent contributor of engineering articles to technical journals. Mr. Lassoe is survived by a widow and one daughter.

Wilbur Wright, who, with his brother Orville, was the first to accomplish mechanical flight, died of typhoid fever at Dayton, Ohio, May 30, aged forty-five years. Wilbur and Orville were bicycle repairers in Dayton when they became

A correct feed for every operation on this piece without shifting a belt



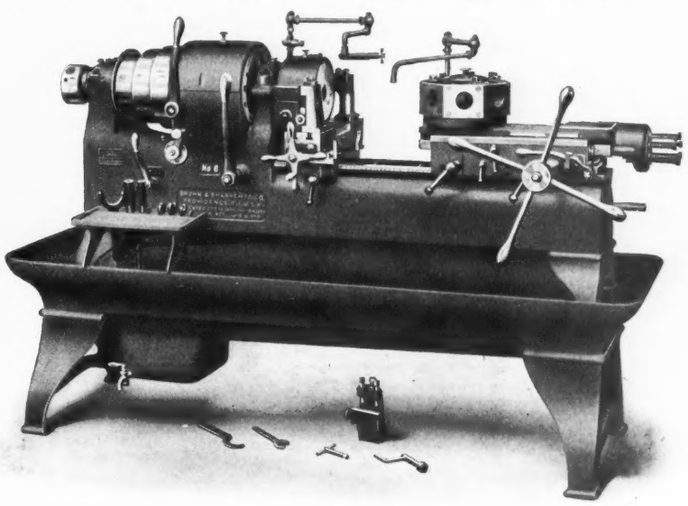
Selecting a feed for the fastest cutting tool and using it for all the others, or an alternative of shifting a belt for each operation are both unsatisfactory from the view points of economy and handiness. That is why

B. & S. Wire Feed Screw Machines

have wide ranges of self-contained feeds for the turret slide

The piece in question requires five turret operations consisting of roughing and finishing the smaller diameter, drilling and reaming the hole, and knurling the larger diameter. These operations necessarily call for a wide variation in feeds. It is possible to obtain a correct feed for each operation on the No. 6 Machine, in which this piece was produced, by the movement of one or both of two levers, one on the turret slide and the other at the headstock. Furthermore **the operator makes these feed changes without stopping the machine or moving from his position.**

Investigate these self-contained turret slide feeds on our Wire Feed Machines.



No. 6 Wire Feed Screw Machine

Write for further information about these machines.

BROWN & SHARPE MFG. CO.

PROVIDENCE, RHODE ISLAND, U. S. A.

interested in aviation. The first experiments were made with gliders, and the first flight with a motor propelled aeroplane was made at Kitty Hawk, N. C., December 7, 1903. This flight of 852 feet was made in 59 seconds. Numerous short flights followed, and on September 26, 1905, a flight of 11⅛ miles was made at Dayton in 38 minutes, 3 seconds, this one being longer than all previous flights put together. The Wright brothers were notable for modesty, reticence and perseverance. They worked under most discouraging circumstances for years before the world recognized that they had actually solved the problem of navigating the air.

* * *

COMING EVENTS

July 9.—Annual convention of the American Railway Tool Foremen's Association in Chicago. H. L. Miller, secretary of the supply association, 835 Monadnock Bldg., Chicago, Ill.

August 20.—Annual convention of the International Railroad Master Blacksmiths' Association at Hotel Sherman, Chicago, Ill. J. E. Carrigan, Rutland Railway, Rutland, Vt., chairman of the executive committee.

September 2-7.—Sixth congress of the International Association for Testing Materials at the Engineering Societies Building, 29 W. 39th St., New York. H. F. J. Porter, secretary, 1 Madison Ave., New York.

September 24-26.—Annual convention of the American Foundrymen's Association and allied bodies, in Buffalo, N. Y.; Hotel Statler, headquarters. Richard Moldenke, Watchung, N. J., secretary.

October 4-26.—International Machinery Exhibition at Olympia, London, England, organized by the Machine Tool and Engineering Association, Ltd.

October 7-11.—Annual convention of the American Electric Railway Association and allied associations in Chicago, Ill. The exhibit will be at Dexter Pavilion, 43d and Halstead Sts. H. C. Donecker, secretary-treasurer, 29 W. 39th St., New York.

SOCIETIES, SCHOOLS AND COLLEGES

CORNELL UNIVERSITY, Ithaca, N. Y., opened Rand Hall May 23 with appropriate exercises. The building, 50 by 170 feet and three stories high, is a memorial to Jasper R. Rand, Jasper R. Rand, Jr., and Addison C. Rand.

NEW HAVEN MANUFACTURERS' EXHIBIT ASSOCIATION, New Haven, Conn., has been organized by the manufacturers of New Haven for the purpose of making a permanent industrial exposition. About eighty per cent of the manufacturers have taken space and installed exhibits in the Auditorium Bldg., 671-673 Chapel St.

NATIONAL METAL TRADES ASSOCIATION, New England Bldg., Cleveland, Ohio. Proceedings of the fourteenth annual convention of the association at the Hotel Astor, New York City, April 11, 1912. The proceedings include a number of valuable technical papers on industrial education, employers' liability and workmen's compensation laws, safeguarding machinery, etc.

UNIVERSITY OF SOUTH CAROLINA, Columbia, S. C. Catalogue for the year 1911-12, together with announcements for the year 1912-13. This catalogue contains the usual information relating to the courses of study, the requirements for admission, and the departments of instruction, together with a list of students. It is illustrated with unusually fine halftones showing the various buildings of the university.

AMERICAN MUSEUM OF SAFETY, 29 W. 39th St., New York. Paper entitled "Boat Installations and other Life-saving Devices for Safety at Sea," prepared by Mr. Axel Welin, of London, England, and read at a meeting under the auspices of the museum at New York, May 9, 1912. The paper is well illustrated with halftones and line engravings showing the arrangement of life boats and davits.

POLYTECHNIC INSTITUTE OF BROOKLYN, Brooklyn, N. Y. Catalogue of the college of engineering 1912-13. This catalogue gives a list of the faculty and instructors, and general information relating to the courses, admission requirements, fees, scholarships, etc. Some interesting information relating to the history of the Polytechnic Institute, its equipment, administration, regulations, and student organizations, is also given, together with a roster of students for 1911-12.

AMERICAN MUSEUM OF SAFETY, 29 W. 39th St., New York. No. 3 of the "Manuals of Safety," covering foundry practice, by Wm. H. Tolman, director of the museum. This little book, consisting of forty 4½- by 7-inch pages, reviews especially the dangers of the foundry and the departments connected with it, and suggests a number of remedies to avoid accidents and injurious effects on the health of the workers. The book is profusely illustrated, and sells at 25 cents.

UNIVERSITY OF WISCONSIN, Madison, Wis., announces that the twelfth annual six weeks' summer school of its College of Engineering opens June 24. Courses of instruction and laboratory practice are offered in electrical, hydraulic, steam and gas engineering, mechanical drawing, applied mechanics, testing of materials, machine design, shop work and surveying, in addition to which, subjects may be taken in the College of Letters and Science. Further information may be obtained from Dean F. E. Turneaure, University of Wisconsin, Madison, Wis.

NEW BOOKS AND PAMPHLETS

THE EVOLUTION OF VERTICAL LIFT BRIDGES. By Henry Grattan Tyrrell, bridge and structural engineer, Evanston, Ill., reprinted from *Applied Science*, 1912.

BOLTS, BASE PLATES AND PLATING FOR STEEL STACKS. By Arthur M. Green, Jr. 16 pages, 6 by 9 inches. Published by the Rensselaer Polytechnic Institute, Troy, N. Y.

AN ANALYTICAL STUDY OF THE ACTION OF THE VACUUM DASHPOT. By Karl Nibecker. 22 pages, 6 by 9 inches, and one folding chart. Published by the University of Pennsylvania Mechanical and Electrical Engineering Department, Philadelphia, Pa.

TWENTY-THIRD ANNUAL REPORT ON THE STATISTICS OF RAILWAYS IN THE UNITED STATES, for the year ending June 30, 1910. 898 pages, 6 by 9 inches. Published by the Interstate Commerce Commission, Washington, D. C.

PROCEEDINGS OF THE THIRTY-FIRST ANNUAL CONVENTION OF THE AMERICAN WATER WORKS ASSOCIATION. Held at Rochester, N. Y., June 9-10, 1911. 490 pages, 6 by 9 inches. Published by the secretary of the society, 47 State St., Troy, N. Y.

STARTING CURRENTS OF TRANSFORMERS. By Trygve D. Yensen. 43 pages, 6 by 9 inches. 18 illustrations. 6 tables. Published by the University of Illinois, Urbana, Ill.

This is bulletin No. 55 issued by the Engineering Experiment Station of the University of Illinois, and deals with the starting currents of transformers with special reference to transformers with silicon steel cores, in which the current may rise to more than seven times the full load current—a phenomenon which is fully explained in the bulletin.

CONSTRUCTING CONCRETE PORCHES. By A. A. Houghton. 62 pages, 5 by 7¼ inches. 18 illustrations. Published by Norman W. Henley & Son, New York. Price 50 cents.

This book is No. 9 in a series of reference books for concrete workers and contains a treatise illustrating and describing the construction of monolithic concrete and concrete block porches, taking up the molding of columns, balusters, lattice work and railings, as well as plain and reinforced types of porch floors. The book is concise and direct in the treatment of its subject.

TESTS OF COLUMNS. By Arthur N. Talbot and Arthur R. Lord. 44 pages, 6 by 9 inches. 20 illustrations. Bulletin No. 56 of the University of Illinois, Urbana, Ill.

This bulletin contains an investigation of the value of concrete as reinforcement for structural steel columns. The tests recorded show that structural steel columns having a filling of concrete, if properly made, develop nearly all the strength of both the steel and concrete. The tests also show that up to the point of failure of the column, the fireproofing shell of the concrete adheres tightly to the remainder of the column.

ELECTRICAL INJURIES. By Charles A. Lauffer. 77 pages, 4 by 6½ inches. Published by John Wiley & Sons, New York. Price 50 cents.

The author of this book is medical director of the relief department of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., and is well qualified to treat the subject here dealt with. The book covers the causes, prevention and treatment of injuries with which workmen and others may meet in connection with electric currents. The book is intended to be of use to practical electrical men, and treats the subject in clear and simple language.

CONCRETE BRIDGES, CULVERTS, AND SEWERS. By A. A. Houghton. 58 pages, 5 by 7¼ inches. 14 illustrations. Published by Norman W. Henley & Son, New York. Price 50 cents.

This book is No. 8 in a series of reference books for concrete workers and contains a treatise illustrating and describing the various types of solid and reinforced arch, slab, and girder concrete bridges, and the molding of concrete culverts, drains and sewers. The book is written in a clear and concise manner and will prove useful also to persons who are not following concrete work as an occupation, but who wish to get a general idea of the methods and principles involved.

AMERICAN EXPORTER'S EXPORT TRADE DIRECTORY. Compiled by B. Olney Hough. 267 pages, 6 by 9 inches. Published by the Johnston Export Publishing Co., New York City. Price $3.00.

This book contains lists of foreign buying agencies in the United States, manufacturers' export agents, New York bankers engaged in foreign exchange business, foreign exchange dealers and brokers, marine insurance companies and export trucking companies in New York City, and foreign freight forwarders. Detailed information of steamship services to foreign parts, a list of consuls of foreign countries in the United States, and of American consulates in foreign countries are also given.

RUBBER HAND STAMPS AND THE MANIPULATION OF RUBBER. By T. O'Conor Sloane. 167 pages, 5 by 7 inches. Published by Norman W. Henley & Son, New York. Price $1.00.

This is a new, revised and enlarged edition in which chapters on the use of rubber in surgery and dentistry and the construction and repairing of rubber tires have been added. The object of the book is, in general, to present in the simplest form the subject of the manipulation of India rubber. Among other subjects the book deals with the making of rubber stamps, rubber type, sheet rubber goods, solution of India rubber, ebonite, vulcanite and gutta-percha, etc.

BRAZING AND SOLDERING. By James F. Hobart. 51 pages, 5¼ by 8 inches. 18 illustrations. Published by Norman W. Henley & Son, New York. Price, 25 cents.

This is the fifth revised and enlarged edition of Mr. Hobart's book, treating of the subject of brazing and soldering. It covers, in general, the same field as the previous editions, giving specific information regarding brazing alloys, and solders, and methods used in brazing and soldering. One chapter is devoted to special methods of soldering and covers electrical work, and tin plate, galvanized iron and zinc, lead and aluminum soldering. Compositions of various solders and fluxes are also given.

COALFIELDS AND COLLIERIES OF AUSTRALIA. By F. Danvers Power. 412 pages, 6 by 8½ inches. 231 illustrations. Published by Critchley Parker, Melbourne, Australia. Price 25s.

While coal mining plays a large part in the mining operations of Australia, this is the first work devoted to this important branch of the commercial activities of the commonwealth. The author, who is a member of the American Institute of Mining Engineers, as well as of the corresponding British and Australian societies, is well equipped to handle this subject, and the book will prove of value to those who are interested in the development of the Australian commonwealth and its mining industries.

KNOTS, SPLICES AND ROPE-WORK. By A. Hyatt Verrill. 102 pages, 4¾ by 6¾ inches. 148 illustrations. Published by Norman W. Henley & Son, New York. Price, 60 cents.

This book is a practical treatise giving complete and simple directions for making the most useful and ornamental knots commonly employed. The book is well illustrated to show the exact methods used in making knots and splices. The contents of the book will be best understood from a review of the chapter headings: Cordage; Simple Knots and Bends; Ties and Hitches; Nooses, Loops, and Mooring Knots; Shortenings, Grommets, and Selvagees; Lashings, Seizings, Splices, etc.; Fancy Knots and Rope Work.

SUPERHEATED STEAM IN LOCOMOTIVE SERVICE. By W. F. M. Goss. 66 pages, 6 by 9 inches. 51 illustrations. Published by the University of Illinois, Urbana, Ill.

This is bulletin No. 57 of the Engineering Experiment Station of the University of Illinois. It gives the results of a study of recent German practice in the use of superheated steam as well as of an elaborate series of tests made upon an American locomotive. The conclusions are to the effect that the use of superheated steam introduces no serious difficulties; that it brings about a material saving in the use of coal and water; and that the power capacity of American locomotives can be readily increased by this means.

DIARY OF A ROUNDHOUSE FOREMAN. By T. S. Reilly. 158 pages, 5 by 7 inches. Published by Norman W. Henley & Son, New York. Price $1.00.

This book contains a number of articles published some years ago by the author in the *Railway and Engineering Review*, under the title "Diary of a Roundhouse Foreman." It is in compliance with many requests that these articles are now put in book form. The author has attempted to give a general idea of the nature and range of problems that a roundhouse foreman has to meet. For this purpose it has been assumed that a typical young machinist has been placed in charge of a roundhouse, and his experiences are set forth in a manner which indicates that the author is a good story teller.

HOUSE WIRING. By Thomas W. Poppe. 103 pages, 4½ by 6½ inches. 74 illustrations. Published by Norman W. Henley & Son, New York. Price, 50 cents

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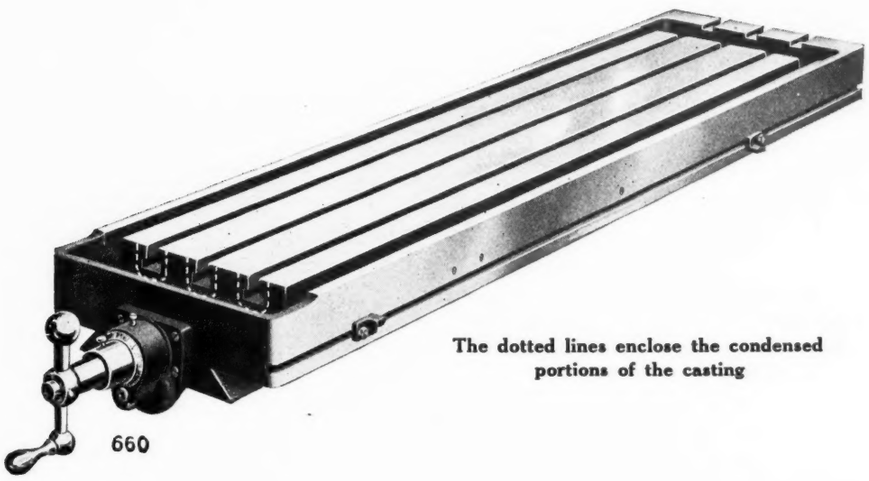

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This book is a treatise describing and illustrating up-to-date methods of installing electric light wiring and is intended primarily for persons of limited experience who wish to obtain a practical knowledge of the installation of electric lighting systems. The subject is treated in a simple and concise manner and illustrations are used throughout the book to clearly convey the ideas presented. The book consists of seven chapters headed as follows: Showing the Plans and Layout of the Electrical Work; Flexible Metallic Wiring Systems; Installing Rigid Conduit; Combining Flexible and Rigid Conduit; Wiring and Switch Diagrams and Connections; Grounding Metallic Conduit Systems; Knob and Tube System.

FARM GAS ENGINES. By H. R. Brate. 195 pages, 5 by 7 inches. 37 illustrations. Published by the Gas Engine Publishing Co., Cincinnati, Ohio. Price $1.00.

This book is intended to present, in a simple way, the methods used in the successful running of gas engines. Examples are given of various troubles met with in the manipulation of these engines, the book being intended especially for persons who use small units for agricultural work on small industrial plants. Special attention has been called to the troubles met with in the ignition system. The language used is clear and simple and well adapted to the class of readers for which the book is intended. The various chapters of the book discuss two- and four-cycle gas engines, fuels, carburetion, compression, ignition, magnetos, batteries, coils, lubrication, cooling, gas tractors, portables, farm pumping plants, farm lighting plants, farm machinery operated by gas engines, and marine engines.

PRIMER OF SCIENTIFIC MANAGEMENT. By Frank B. Gilbreth. 108 pages, 5 by 7½ inches. Published by D. Van Nostrand Co., New York. Price $1.00.

In the early part of 1911 the *American Magazine* published a series of articles by Frederick W. Taylor, entitled "The Principles of Scientific Management." As a result of the publication of these articles, hundreds of letters were sent to the magazine requesting further information on the subject. These letters were all handed to the author of the present book and are answered in it. Hence, the book is not a complete treatise on scientific management, but gives in a catechism form a comprehensive idea of the main principles of the subject. The book is divided into five chapters headed as follows: Definitions of Terms of Scientific Management; Laws, or Principles, of Scientific Management; Application of the Laws of Scientific Management; The Effect of Scientific Management on the Worker; and Relation of Scientific Management to Other Lines of Activity.

ELEMENTARY INTERNAL COMBUSTION ENGINES. By J. W. Kershaw. 171 pages, 5¼ by 7¾ inches. 117 illustrations. Published by Longmans, Green & Co., New York. Price, 90 cents.

The author of this book, who is a lecturer in engineering at the University of Sheffield, England, states in the preface that it is intended to give an elementary account of the construction and working of internal combustion engines and power gas producers, and thus to serve as an introduction to the more advanced books dealing with the subject. The explanations have, for this reason, been made as simple as possible, but within its scope the book is thorough and comprehensive and provided with a great number of sectional illustrations showing the exact workings of the various parts of the gas engine. The contents by chapters are as follows: The Gas Engine; Large Gas Engines; Gas Engine Governing; Ignition; The Indicator and Indicator Diagrams; Calorific Power; Gas Producers; Theory of Gas Producers; Oil Engines; Petrol Engines; Oil Engines for Ships; Other Combustion Motors; Engine Efficiency.

CONCRETE COSTS. By Frederick W. Taylor and Sanford E. Thompson. 709 pages, 5 by 8 inches. 82 illustrations. Published by John Wiley & Sons, New York. Price, $5.00.

This book is designed to meet the needs of both the contractor and the engineer and architect in making rough and approximate as well as accurate and detailed estimates. It is also intended to make possible an economical layout and a scientific management of the work in combination with task and bonus systems. The book contains an immense amount of data relating to all phases of concrete work and it is impossible in a brief review to give more than a general idea of its contents. It has twenty-three chapters which are headed as follows: Approximate Costs of Miscellaneous Concrete Work; Approximate Cost Data on Concrete Structures; Approximate Costs of Reinforced Concrete Buildings; Determination of Labor Cost; Task-work in Construction; Proportioning Concrete; Tables of Quantities of Materials for Concrete and Mortar; Cost of Concrete Materials; Excavating and Crushing Stone for Concrete; Handling and Transporting Materials; Labor of Hand Mixing; Machinery Plants for Mixing and Handling Concrete; Labor Costs of Machine Mixing; Forms for Mass Concrete; Arch Centers; Forms for Reinforced Concrete; Tables of Concrete Volumes; Tables of Steel Areas and Quantities; Tables of Times and Costs Bending and Placing Steel; Tables for Designing Forms; Tables of Quantities of Lumber for Forms; Tables of Times and Costs of Labor on Forms; Estimates for Reinforced Concrete Construction.

PRACTICAL THERMODYNAMICS. By Forrest E. Cardullo. 411 pages, 6 by 9 inches. 224 illustrations. Published by McGraw-Hill Book Co., New York. Price $3.50.

While this book is intended primarily as a textbook for the use of classes in mechanical and electrical engineering, it is written in a manner which will appeal especially to the practical man. The author has presented his subject so that any person who would like to obtain a general understanding of thermodynamics without going into the subject deeply enough to analyze the mathematical deductions, will be able to do so without difficulty. The book has been prepared with a clear view of both practical and theoretical considerations, and the laws which underlie the action of thermodynamic apparatus are so presented that the reader will not only be able to comprehend the principles involved, but also to correctly design apparatus based upon these thermodynamic principles. The book has a pleasing and refreshing touch of originality, and as the writer himself states in the preface, he has not hesitated to present new methods whenever these methods seemed simpler and better than the older ones. Many of the definitions given, therefore, differ radically from those found in other textbooks, and the whole subject has, as a result, become more simple and also more logical. Such items as can only be fully comprehended and satisfactorily studied by more advanced students have been printed in smaller type, so as to distinguish them from the remainder of the text. In this way, it is possible for students who have advanced further to deal with the subject in a most thorough manner, while beginners may read only such parts as are especially intended for them at their present stage of development. A great number of problems for exercises are presented, these problems being given at the end of each chapter. The answers accompany the problems in each case. The general scope of the work will be best understood from a review of the headings of the chapters of the book: The Nature and Measurement of Heat; The Thermal Properties of Gases; The Expansion of Gases; Thermodynamic Processes and Cycles; The Thermal Properties of Vapors; Wet and Superheated Vapors; Mixtures of Gases and Vapors; The Steam Engine; Steam Cycles; Losses in the Steam Engine; Notes on the Design and Testing of Steam Engines; The Steam Turbine; Condensing Machinery; Combustion; The Steam Boiler; Boiler Plant Auxiliaries; Water-cooling Apparatus; Hot-air Engines; The Internal Combustion Engine; Notes on the Design and Performance of Internal Combustion Engines; Gaseous Fuels; Compressed Air; Refrigeration; Heating, Ventilation, Evaporation and Drying; Entropy Diagrams; The Kinetic Theory of Heat.

NEW CATALOGUES AND CIRCULARS

NELSON VALVE CO., Chestnut Hill, Philadelphia, Pa. Catalogue S on steel valves and fittings made of acid open-hearth steel.

NATIONAL TUBE CO., Frick Bldg., Pittsburg, Pa. Circular describing the N. T. C. regrinding globe and angle valves with union bonnet.

DAVIS-BOURNONVILLE CO., 97 West St., New York. Booklet No. 4 on autogenous welding and cutting of metals by the oxy-acetylene process.

WAYNE OIL TANK & PUMP CO., Fort Wayne, Ind. Circular of oil storage outfits for gasoline, gasoline lubrication oils, paint oils and varnishes.

DEANE STEAM PUMP CO., 115 Broadway, New York. Bulletin D-171 on horizontal duplex piston pumps, operated by direct-connected vertical gasoline engines.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J. Booklet on Joseph Dixon, comparing his work with that of others who have made great inventions and discoveries.

MCEWEN BROS., Wellsville, N. Y. Booklet illustrating and describing pumps for steam turbine drive. Complete description and tables of necessary data are given.

TAYLOR IRON & STEEL CO., High Bridge, N. J. Bulletin No. 114 briefly describing the application of "Tisco" manganese steel to crusher and pulverizer parts.

C. W. MEADOWCROFT, SR., 4702 Large St., Frankford, Philadelphia, Pa. Circular illustrating the ball high-speed rotary riveting hammer, with foot lever, bench style.

O. N. BECK, 11 Queen Victoria St., London, E. C., England. Circular of elastic corrugated tubes for expansion joints, heating and smoke tubes, superheaters, condensers, etc.

DETROIT FUSE & MFG. CO., Detroit, Mich. Bulletin No. 25 descriptive of "Detroit" switches for motor-operated machinery which are "foolproof, fireproof and fumeproof."

PETERS BROS. MFG. CO., Algonquin, Ill. Circular of "Peters" abrasive metal saw for cutting high-speed steel, brass, copper, iron pipe tubing, and all metals; price, $16.50.

NATIONAL SCALE CO., Chicopee Falls, Mass. Folder advertising the National counting machine for parts such as bolts, screws, nuts, etc., used in quantities in manufacturing establishments.

INGERSOLL-RAND CO., 11 Broadway, New York. Bulletin No. 7004 illustrating and describing Cameron steam pumps, remarkable for the small number of working parts used in their construction.

TREADWELL ENGINEERING CO., Easton, Pa. Booklet on steel castings, defining what steel castings are. The information contained will be useful to any user or prospective user of steel castings.

BETHLEHEM STEEL CO., S. Bethlehem, Pa. Catalogue of crucible steel products comprising high-speed steel, carbon steel, die products, forged disks and blanks, special alloy steel, spring steel, etc.

HESS-BRIGHT MFG. CO., 2111 Fairmount Ave., Philadelphia, Pa. Catalogue on the Hess-Bright DWF ball bearing hangers for lineshafting, illustrating installations and giving data on power saving.

WELLS BROS. CO., Greenfield, Mass. Circular of the "Little Giant" tap grinder which provides means for sharpening taps up to 12 inches in length and, with special arm, to 15 inches in length; price, $75.

WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburg, Pa. Descriptive leaflet No. 2496 on Westinghouse outdoor type OISC transformers; circular No. 1194, on Westinghouse type Q direct current generators.

NATIONAL AUTOMATIC TOOL CO., Richmond, Ind. Catalogue of automatic adjustable multiple spindle, vertical and horizontal drilling machines with variable spindle speeds, for drilling, reaming and tapping.

SHEPARD ELECTRIC CRANE & HOIST CO., Montour Falls, N. Y. Bulletin descriptive of the Shepard line of cage controlled monorail electric hoists for use in steel mills, foundries, machine shops and factories.

CROCKER-WHEELER CO., Ampere, N. J. Bulletin No. 141, illustrating and describing alternating current motors, Form R, induction type, designed for operating from 25 cycle polyphase alternating current circuits.

PENNSYLVANIA RAILROAD CO., Philadelphia, Pa. Booklet on the subject of corn culture, intended for farmers, students in agricultural schools and others interested in the promotion of higher agricultural efficiency.

STANDARD PUMP & ENGINE CO., Cleveland, Ohio. Catalogue No. 12 of "Standard" pumping engines, and "Standard" water supply systems adapted to shallow wells, cisterns, lakes, rivers, etc.; also to deep wells.

S. F. BOWSER & CO., Fort Wayne, Ind. Catalogue of the Bowser oil filtration and circulating systems which filter the oil, precipitate impurities, separate and automatically eject water and provide for the storage and use of refuse oil, etc.

DEANE STEAM PUMP CO., 115 Broadway, New York. Catalogue of duplex horizontal double acting power pumps, giving brief descriptions of various types of these pumps, together with complete tabular data relating to capacity and sizes.

GENERAL ELECTRIC CO., Schenectady, N. Y. Bulletin No. 4931. "Electricity in the Shoe and Leather Industry"; bulletin No. 4939. "Electric Hoists"; bulletin No. 4947, "Edison Mazda and Gem Lamps for Standard Electric Railway Service."

ALVAN MFG. CO., Newark, N. J. Leaflet illustrating and describing the "Rex" universal test indicator for the use of toolmakers, machinists, etc., on bench lathes, engine lathes, planers, shapers or milling machines. The error is multiplied fifty times, and the capacity is 0.020 inch.

WELLS BROS. CO., Greenfield, Mass. Tables of tap drill sizes for U. S. standard, S. A. E. standard and machine screw threads. The tap drill sizes are based on the formula $X = N - \frac{3}{4}(2D)$ in which X equals tap drill diameter, N, diameter of tap over top of thread, and D depth of thread.

B. F. STURTEVANT CO., Hyde Park, Mass. Catalogue No. 190 of steam turbines, describing the new type Sturtevant turbine and calling attention to its advantages. Catalogue No. 200 describing the Sturtevant aeronautical motor which is of the four-cycle type with four and six cylinders arranged vertically.

BROWN HOISTING MACHINERY CO., Cleveland, Ohio. Catalogue "J." 1912, covering pillar cranes, hand wrecking cranes, mast jib cranes, pillar jib cranes, bracket jib cranes, hand bridge cranes, and transfer tables. The catalogue is profusely illustrated, showing cranes installed in various industrial plants and for various services.

WISCONSIN ENGINE CO., Corliss, Wis. Circular of the Adams Wisconsin kerosene gas engines, built in sizes from 50 to 200 H. P., under the M. Rumely Co. patents. These engines use kerosene instead of gasoline, being provided with special carburetors that gasify cold kerosene the same as gasoline is gasified in an ordinary carburetor.

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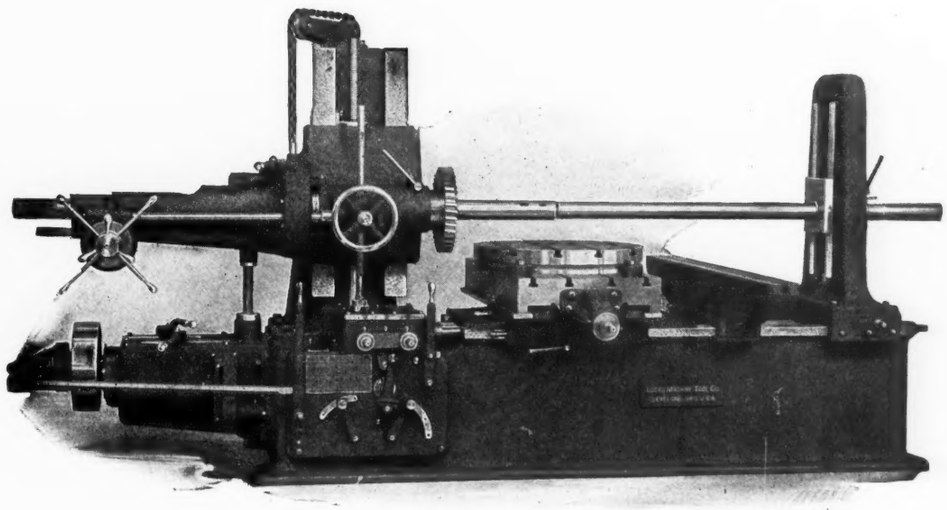

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INDUSTRIAL INSTRUMENT CO., Foxboro, Mass. Bulletin No. 62 descriptive of Dr. Th. Horn's tachometers and tachographs, covering a great variety of styles, ranges and purposes for practically all conditions of industrial and engineering service and including precision tachographs for recording minute variations in speeds of machinery.

STOW MFG. CO., Binghamton, N. Y. Catalogue of flexible shafts and other portable apparatus for drilling, tapping, reaming, counterboring, etc.; also center grinders, portable grinders, scratch brushes, universal joints, multi-speed electric motors, electric grinders of the floor and portable types, track drills, rail grinders, hand buffers, electric bench grinders, electric breast drills, etc.

THOMSON ELECTRIC WELDING CO., Lynn, Mass. Catalogue of electric welding machines operating by the resistance or Thomson process which is principally employed in butt welding, T- and angle-welding, cross welding, lap welding, seam welding, etc. A line of machines adapted to a large variety of welding operations is illustrated, and data on size, weight, capacity, etc., are given.

AMERICAN TOOL WORKS CO., Cincinnati, Ohio. Pamphlet describing methods employed in the manufacture of lathes, planers, shapers and radial drills in Cincinnati, by the company. The tests applied are shown. The pamphlet should be found of much general interest to superintendents, foremen, mechanics and all interested in any way in machine tools.

WESTINGHOUSE ELECTRIC & MFG. CO., E. Pittsburg, Pa. Descriptive leaflet No. 2458 on Westinghouse type-T direct current turbo-generator, consisting of a steam turbine and generator mounted on a common base. The leaflet gives a description of the various characteristics and construction in detail of the steam turbine, and views of the component parts of the various elements, etc.

JOHN M. ROGERS WORKS, INC., Gloucester City, N. J. Catalogue of measuring instruments of precision, manufactured after the Richards system; also solid adjustable blade reamers, solid reamers, adjustable blade hollow mills, adjustable thread cutting tools, steel mandrels, etc. The catalogue includes complete metric sizes and prices of all tools manufactured by the company.

MODERN MACHINE TOOL CO., 4657 Spring Grove Ave., Cincinnati, O. Circular of the "Modern" flat turret lathe embodying improved automatic chuck, automatic roller feed, novel belt clutch, improved friction clutch and improved feed box. The lathe has a capacity for bar stock up to 2¼ inches diameter, and 26 inches length. The swing over the bed is 20 inches and over the carriage, 14 inches.

FAHRIG METAL CO., 34 Commerce St., New York. Circular of "Fahrig" anti-friction metal, composed of tin and copper combined by a special process. This metal is especially valuable for the bearings of automobiles and gas engines. It has superior anti-friction qualities and can be used in the form of die castings, sand castings or poured bearings, as may be required to suit the condition of manufacture.

PENNSYLVANIA RAILROAD CO., Philadelphia, Pa. Booklet entitled "The Pennsylvania Railroad and Industrial Safety," containing extracts from the proceedings of the American Museum of Safety, New York, January 17, 1912, when the Traveler's Insurance Co's medal was awarded to the Pennsylvania Railroad, "as the American employer who, in 1911, did the most to protect the lives and limbs of its employes."

VAN DORN & DUTTON CO., Cleveland, Ohio. Circular illustrating uses of the Van Dorn & Dutton Co., hard-service portable electrically-operated drills and reamers, the examples showing application to car work, structural work, manufacture of steel furniture, motor cars, drilling armor plate, erecting lineshafts, boring holes in timber, drilling staybolt holes in boilers, erecting elevators, repairing stationary engines, etc.

GENERAL ELECTRIC CO., Schenectady, N. Y. Bulletins No. 4880, on railway signal volt ammeters; 4910, on oil break switches; 4925, on combined unit-series mercury arc rectifier outfit; 4938, on Type H transformers; 4949, on direct-current portable instruments; 4950, on Washington, Baltimore & Annapolis 1200-volt direct-current railroad installation; 4951, on street lighting with Edison "Mazda" series lamps; and 4952, on series incandescent street lighting systems.

HOSKINS MFG. CO., 459 Lawton Ave., Detroit, Mich. Bulletin No. 10 descriptive of the "Hoskins" electric muffle furnaces, type FC, for the efficient heat-treatment of tool steels, made in two sizes having chamber dimensions 6½ inches wide by 5 inches high by 12 inches deep, and 12 inches wide by 8 inches high by 18 inches deep, respectively. Among the advantages claimed are even heating, accurate temperature, atmospheric control, absence of oxidizing gases, rapid heating, high thermal efficiency, etc.

BUSCH-SULZER BROS.-DIESEL ENGINE CO., St. Louis, Mo. Pamphlet entitled "The Present Status of the Diesel Engine in Europe and a Few Reminiscences of the Pioneer Work in America," by Dr. Rudolf Diesel, the contents comprising a lecture delivered before the Associated Engineering Societies of St. Louis, April 13, 1912. The growing importance of the Diesel internal combustion engine makes the pamphlet of much interest to engineers and others concerned with the economical generation of power.

AMERICAN SWISS FILE & TOOL CO., 24 John St., New York. Catalogue, fifth edition, of "American Swiss" files, fully illustrated, with price list in distinctive heavy type. A separate sheet accompanying the catalogue compares "American Swiss" list and "American Standard" list, this comparison being important to buyers of high-grade files. The inside front cover concerns trademarks, and the inside back cover briefly takes up the three epochs in file making beginning with a well-known quotation from the Bible. The engravings of files are carefully made showing the kind of cutting exactly. File users generally will find the catalogue interesting and valuable for reference.

BRISTOL CO., Waterbury, Conn. Catalogue No. 1000 on Bristol's recording gages for pressure and vacuum, containing 64 pages, 8 by 10½ inches. The catalogue lists all of the Bristol recording pressure and vacuum gages except round form models 50, 52 and 56. These gages are furnished with charts graduated in pounds per square inch, in ounces per square inch, in inches head of water, in feet head of water, in atmospheres, in inches head of mercury, in centimeters head of water, in decimeters head of water, in tons, in kilograms per square centimeter, in millimeters head of mercury, in millimeters head of kerosene, in centimeters head of water, in millimeters head of water, etc. The preceding partial list gives some idea of the extent of development of the recording gage, exemplified by the product of the company.

INTERNATIONAL OXYGEN CO., 115 Broadway, New York. Bulletins on the I. O. C. oxy-hydrogen platinum melting processes; the Holder pressure generator for generating acetylene gas; welding torches for welding metals; high-pressure cylinders for gas, made in 100, 150 and 200 cubic feet capacities, respectively; report of tests of cells for the electrolytic production of oxygen and hydrogen made by the Electrical Testing Laboratories, New York; oxy-hydrogen and street railway construction, being extracts from paper read by Mr. Henry Mozley before the convention of the Municipal Tramways Association held at Glasgow, September 27-29, 1911; and bulletin containing tables on weights of gases, variation of pressures in cylinders with variation of temperature, quantity of gas remaining constant; quantity of gas in cylinders under various pressures, temperature constant; purity of oxygen; and calculation of thermometer readings, etc.

TRADE NOTES

CROCKER-WHEELER CO., Ampere, N. J., opened an office in the Title Insurance Bldg., in Los Angeles, Cal., April 1.

MORROW MFG. CO., Elmira, N. Y., is building a one-story brick addition, 50 by 180 feet for an automatic turret lathe department.

SUPERIOR MACHINE TOOL CO., Kokomo, Ind., is building an addition to its plant to afford necessary facilities for its increasing business.

THE TRUTH
ABOUT
HOLLOW SET SCREWS

Pioneers in the promotion of new things are to be pitied. The study, the anxiety, the worry and expense of marketing anything new may bring their measure of success, but surely will bring (on any article of merit) competition, fair and unfair.

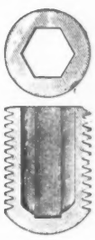
Many years ago we began the sale of Hollow Set Screws and while a Hollow Set Screw is not new, yet our method of producing them was new and produced a very much better screw than can be made from the solid bar, drilled and broached. In these solid bar screws, the surplus metal at the point at first appears to be advantageous, but in reality it is disadvantageous for the reason that the uniform thickness of our screws made from flat steel "died" out, permits a longer hold on the wrench and, therefore, a far better opportunity for tightening, while in the solid screw which is drilled and broached, it is necessary to turn in the surplus metal (resulting from the broaching) to the bottom of the hole, thereby partially filling the hole with nothing but waste material which has absolutely no holding power at all.

The H.S.&Co. Screws are made from sheet steel, stamped or "drawn up." Proper tests prove beyond a doubt that this method makes a stronger and tougher screw than one milled from the solid bar, owing to the position of the fibres of the steel. Well known proof of this is found in the comparative values of semi-finished nuts—those milled from solid rod not being as strong as the stamped goods; the same is illustrated also in wood, the plank grain being infinitely stronger than the cross grain product.

We invite comparative tests of the H.S.&Co. Hollow Set Screws with any other screws made having a hole or socket, and will supply FREE SAMPLES for this purpose, to reputable concerns.

SEND FOR CIRCULAR No. 3055.

HAMMACHER, SCHLEMMER & CO.



HARDWARE, TOOLS AND SUPPLIES

New York, Since 1848 **4th Ave. and 13th St.**

BLAKESLEE FORGING CO., Southington, Conn., will erect a new forge shop 30 by 160 feet, three stories high; also an annealing shop 32 by 72 feet, one story high.

WATERBURY FARREL FOUNDRY & MACHINE CO., Waterbury, Conn., has awarded the contract for the construction of a new machine shop 68 by 184 feet, one story high.

FREVERT MACHINERY CO., 38 Vesey St., New York, the business of which has been conducted since its inception in 1906 by H. F. Frevert, has been enlarged and papers for incorporation under the laws of the State of New York have been filed.

LUMEN BEARING CO., Buffalo, N. Y., is making an addition of 1800 square feet to its plant to take care of aluminum casting work. The company reports a prosperous year up to date, orders received being in excess of those reported for corresponding periods in the past.

H. W. JOHNS-MANVILLE CO., Madison Ave. and 41st St., New York, has moved its Winnipeg branch offices into new quarters at 92 Arthur St. The new place is a six-story and basement building, and will be occupied throughout by the company's offices and store-rooms.

BROWN & SHARPE MFG. CO., Providence, R. I., announces that its works will be closed from August 2 to 19 for the annual vacation. During this time the offices will be open as usual and orders for machine tools, machinists' tools and cutters will receive the same attention as at any other period of the year.

WELLS BROS. CO., Greenfield, Mass., manufacturer of taps and dies, has opened a store in Boston at 163 Oliver St. A comprehensive stock of all screw-cutting tools is carried, and quick deliveries will be made, thus affording better service to the trade in Boston and vicinity. Mr. John E. Chipman is manager of the new store.

WATSON-STILLMAN CO., 192 Fulton St., New York, announces that the following officers were elected at a directors' meeting, May 15: President, E. A. Stillman; vice-president and secretary, A. F. Stillman; treasurer, J. P. Bird; chief engineer, Carl Wigtel; superintendent, Frank Lary. A new branch office is to be opened at Philadelphia soon and the shop facilities are being improved to meet increasing business.

BALDWIN CHAIN & MFG. CO., Worcester, Mass., has appointed Mr. Charles D. Schmidt its local representative in Greater New York City. An office and storerooms have been established at 416 Broadway, and Mr. Schmidt will give his attention to the prompt delivery of orders for the local trade. The company makes sprockets as well as chains, and Mr. Schmidt is prepared to furnish sprockets and chains for replacements on standard commercial cars.

UNIVERSAL MACHINE SCREW CO., Hartford, Conn., recently opened a New York office in charge of Mr. C. D. Schmidt, manager, corner Broadway and Canal St. (entrance 276 Canal St.) which will expand the facilities required for the increasing business of the company. The company manufactures the "Universal" five-spindle automatic screw machine and also operates a large number of these machines in its own plant, producing standard and special screw machine products from steel or brass. Mr. Schmidt, the New York manager, has been an important factor in the machine screw product field for a number of years.

E. F. LAKE, Bayonne, N. J., has merged his consulting metallurgical business with the metallurgical engineering firm of Nixon & Raab under the name of Lake, Nixon & Raab, 156 Fairview Ave., South Orange, N. J. Die-casting machinery alloys and processes, and heat-treatment and carbonizing of steel will be specialized on. All kinds of physical tests and chemical analyses will be given to various metal products, and advice will be given as to the best methods and machinery used in the melting of all alloys, casting alloys, galvanizing, coloring and plating, or otherwise working and treating either ferrous or non-ferrous metals or alloys.

VAN DORN & DUTTON CO., Cleveland, Ohio, has opened several new agencies for the sale of its portable tools only. Stock will be carried in the following places: 67 Main St., San Francisco, Cal., W. B. Wilson, district manager; Security Bldg., Los Angeles, Cal., J. L. Davidson, district manager; Candler Bldg., Atlanta, Ga., W. F. Davis, district manager; Alfred Herbert & Co., Ltd., England, Ireland, Scotland, Wales, France, Belgium, Spain and Portugal; Frank Saunders, Sydney, Australia, Australia and New Zealand. The company reports a largely increased business. A full line of electric grinders will be brought out in the near future.

NEWARK GEAR CUTTING MACHINE CO., Newark, N. J., has again found it necessary to enlarge its works, to take care of increasing business. The assembly room has been enlarged so that the main building now extends from 66-68 Union St. through to 67-69 Prospect St. The three-story brick building at 69 Prospect St. is now occupied by the offices, drawing-room, and pattern-shop; while such portions of the main building as were formerly occupied by these departments will now be given over to the machine shop. The address of the office is now 69 Prospect St., Newark, N. J. Mr. Henry E. Eberhardt, president of the company, reports that at present the plant is running at normal time, with full working force. The demand for gear-cutting machines has been increasing, especially for the Eastern trade.

MISCELLANEOUS

Advertisements in this column, 25 cents a line, ten words to a line. The money should be sent with the order. Answers addressed to our care will be forwarded. Original letters of recommendation should not be enclosed to unknown correspondents.

AGENTS IN EVERY SHOP WANTED to sell my sliding calipers. Liberal commission. ERNST G. SMITH, Columbia, Pa.

DESIGNING, DETAILING and Blue Printing at reasonable rates. E. B. STAUFFER, Ephrata, Pa.

DRAFTING.—Assembly and detail working drawings and tracings of all kinds made on short notice. Mechanical drafting in all its branches. INDUSTRIAL ENGINEERING CO., 192 Market St., Newark, N. J. Open evenings.

DRAFTSMEN AND MACHINISTS.—American and foreign patents secured promptly; reliable researches made on patentability or validity; twenty years' practice; registered; responsible references. EDWIN GUTHRIE, Corcoran Building, Washington, D. C.

DRAWING.—I am thoroughly equipped to make mechanical, electrical, structural and ornamental iron drawings at reasonable rates. Submit sketches and data for rock bottom prices. Life long experience. Reference, First National Bank, Evansville, Ind. D. A. BRADING, M. E., 208 Upper 4th Street, Evansville, Ind.

ENGINEERING DATA.—Send for monthly list of shop and drafting-room data. S. C. CARPENTER, 153 Homestead Ave., Hartford, Conn.

ENGINEERS, SUPERINTENDENTS, Designers, Draftsmen, Engineering Salesmen, Production Engineers and Mechanical Foremen will find it to their advantage to investigate our method of securing employment. Unless record can stand investigation don't bother about answering this ad. THE ENGINEERING AGENCY, INC. (Est. 1893), Monadnock Block, Chicago.

FOR SALE.—ALL or a CONSIDERABLE PART of a $200,000.00 MANUFACTURING BUSINESS, largely in the metal line. Location the best, good buildings, well equipped with up-to-date machinery, excellent staff of skilled workmen. Unusually good relations with employees; never an hour of labor troubles. Business on a prosperous, money-making basis, built up in a few years from a very small beginning from its own profits, and capable of rapid increase in capacity and value.

Reason for selling, old age of the principal owner. On certain conditions would retain large or small part of ownership, in which case it would be deemed an advantage to have the purchase divided among a number, especially if all or part of the investors were qualified to take an active part in the work or management. Address Box 462, care MACHINERY, 49 Lafayette St., New York.

FOR SALE—NEWMAN WATCHMAN'S CLOCK or time detector fitted complete for nine stations. Just as good as new. THE GIER & DAIL MFG. CO., Lansing, Mich.

FOR SALE.—Small power plants, steam or gas. Send for list. J. L. LUCAS & SON, Bridgeport, Conn.

INSTRUCTORS, PROFESSORS and Assistant Professors wanted for engineering positions. Every Spring and Summer we are flooded with inquiries from the various technical colleges of America for men experienced as Instructors in Mechanical, Civil, Structural, Mining, Chemical, Electrical and Hydraulic engineering. We handle engineering exclusively. Investigate our methods. THE ENGINEERING AGENCY, INC. (Est. 1893), Monadnock Block, Chicago.

MACHINE TOOL SALESMAN FOR AUSTRIA, speaking German and Bohemian, capable of demonstrating efficiency of modern Machine Tools. Give details of past experience, state references, nationality, age, salary, etc., in applying to Box 463, care MACHINERY, 49 Lafayette St., New York.

MACHINISTS, TOOL-MAKERS, new vest pocketbook, most needed rules, tables, general and economic information. List of shops, 16 colored maps. Blank memoranda. 120 pages. In leather finished covers, 35c. WM. CUTHBERTSON, 37 Springside Avenue, Pittsfield, Mass. Agents wanted.

PARTNERSHIP.—GERMAN MACHINIST, with technical education, and practical experience of many years in building machinery and in tool making, would like to put small amount of capital into partnership with reliable firm. Address Box 469, care MACHINERY, 49 Lafayette St., New York.

PATENTS.—H. W. T. JENNER, patent attorney and mechanical expert, 608 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact cost. Send for full information. Trade-marks registered.

POSITION WANTED.—As superintendent of machine shop foundry, etc. Capable of handling a large shop on high grade work. Address Box 461, care MACHINERY, 49 Lafayette St., New York.

PRODUCTION MAN, now employed, wants place to stimulate output and quality. Engineering training. Several years' experience in design and manufacture of high-grade steam machinery. Can take charge of shop if desired. Address Box 465, care MACHINERY, 49 Lafayette St., New York.

SITUATION WANTED.—Assistant Superintendent or Foreman, 30 years' experience on tool and machine work. 20 years in charge of men. Address P. O. Box 2081, Bridgeport, Conn.

SITUATION WANTED—FOREMAN, 30 years of age, executive, all-round mechanic. Engines, electrical and general machinery, medium and heavy work; understands Taylor system. Address Box 468, care MACHINERY, 49 Lafayette St., New York.

SITUATION WANTED.—GENERAL FOREMAN, practical experience, thoroughly familiar with all kinds of machine work, expert mechanic, capable of handling a good sized job and get results, hold men and keep them satisfied; used to piecework. References, permanent position. Address Box 466, care MACHINERY, 49 Lafayette St., New York.

SPECIAL MACHINERY and tools designed and detailed. Terms reasonable. S. C. CARPENTER, 153 Homestead Ave., Hartford, Conn.

SUPERINTENDENT with several years' experience on high-grade machine work under the Premium Plan, seeks place as assistant to successful superintendent working on the Bonus System. Engineering Graduate, age 32, energetic. Address Box 464, care MACHINERY, 49 Lafayette St., New York.

TEST INDICATORS.—H. A. LOWE, 1374 East 88th St., Cleveland, Ohio.

WANTED.—Agents, machinists, toolmakers, draftsmen, attention! New and revised edition Saunders' "Handy Book of Practical Mechanics" now ready. Machinists say, "Can't get along without it." Best in the land. Shop kinks, secrets from note books, rules, formulas, most complete reference tables, tough problems figured by simple arithmetic. Valuable information condensed in pocket size. Price postpaid $1.00, cloth; $1.25, leather with flap. Agents make big profits. Send for list of books. E. H. SAUNDERS, 216 Purchase St., Boston, Mass.

WANTED.—By large pump manufacturer, draftsmen with several years' experience, capable of detailing from layouts and doing simple designing under direction of leading men. State fully experience, education, age, reference, pay expected, etc. Write DRAFTSMAN, care MACHINERY, 49 Lafayette St., New York.

WANTED.—Experienced B. & S. automatic screw machine operator, preferably also familiar with the Hartford automatics. Address Box 470, care MACHINERY, 49 Lafayette St., New York.

WANTED—INSTRUCTORS in Mechanical Engineering and in Mechanical Drawing at an Eastern Institution. Applicants must be graduates of technical schools, preferably with one or two years' practical experience. Give full details of education, experience and salary expected. Address Box 467, care MACHINERY, 49 Lafayette St., New York.

WANTED.—TOOL DESIGNER, man with experience in Designing and Machinery. Reply to EMPLOYMENT, Box 911, Pittsburg, Pa.

WELLES TOOLS are different. Get a catalogue and price list. WELLES CALIPER COMPANY, Milwaukee, Wis.